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Lovell Mfg. Co.'s Power Plant

INSTALLATION OF SYNCHRONOUS CONDENSER IMPROVES POWER FACTOR. SAWDUST FORMS PART OF FUEL SUPPLY

DURING THE PAST DECADE most industries, in addition to their need for more efficient machinery, have realized the advantages of centralized prime movers and a system whereby the amount of power used in each department could be accurately determined and recorded.

At Erie, Pa., the Lovell Mfg. Co. has a daily production of 2500 clothes wringers, 70,000 mouse traps and 10,000 rat traps, the factory being divided into 3 departments—rubber, woodworking, and iron. In the early history of this factory, steam engine drives were widely scattered about the buildings, but 8 yr. ago, when H. Edsil Barr, consulting engineer of Erie, was called upon to analyze the situation with a view to modernizing the power machinery, increasing the capacity, flexibility and economy of operation, it was decided to erect a central power station and install motor drives.

Induction motors are employed throughout the factory, the rubber woodworking and iron departments having a total motor load of 650 hp., while the lighting amounts to about 50 kw. Low-pressure steam, with indirect radiation in the factory and direct radiation in the offices, is employed for heating seven acres of floor space, and also supplied to the wood drying kilns. Steam for the main units is generated in the boilers at 150 lb. pressure, and a small amount, upon being reduced to 100 lb., is piped to the fan blower engines and rubber vulcanizers.

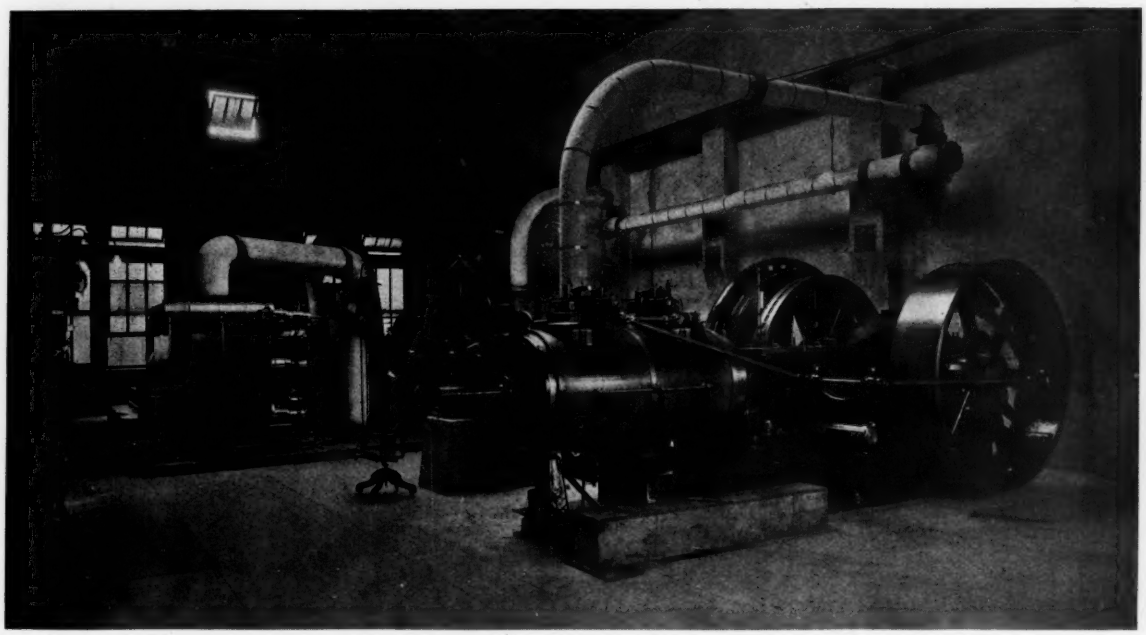


FIG. 1. ENGINE ROOM VIEW

SAWDUST AND WOOD CUTTINGS FURNISH PART OF FUEL

FROM a receiving hopper beneath a track alongside the power house, coal passes through a regulating valve and slides to the boot of a Link-Belt Co. bucket elevator having a 54-ft. rise, from which a short 12-in. screw conveyor transfers it at right angles to a main 12-in.

screw conveyor 50 ft. in length extending over the 200-ton boiler room bunker constructed of ¼-in. plate with a concrete lining. From the bunker, coal is fed to the stokers through spouts flared at the bottom.

Considerable sawdust and wood cuttings were available for fuel, and one of the 4 300-hp. Erie City water-tube boilers was equipped with a wood-burning dutch-oven furnace, the remaining 3 boilers being fed by chain grate stokers, operated by eccentrics from an engine-driven stoker shaft beneath the floor. These boilers are of the horizontal 2-drum type, feed water being carried through 1½-in. branches to a point at the forward end of the inclined pans at the rear of the drums. Blowoff connections of 1½-in. pipe lead from these pans and from the bottoms of the rear headers.

Sawdust is supplied to the wood burning boiler independently of the coarser material, the sawdust duct extending to a collector mounted upon the boiler house roof from which it is spouted to the stoker as shown in Fig. 2. Wood cuttings and small blocks are hauled to the boiler room floor in small trucks and shoveled into

FIG. 2. BOILER ROOM SHOWING WOOD-BURNING FURNACE

the furnace. As the wood supply is insufficient for a 24-hr. boiler run, coal is fed during the night and also occasionally during the day to maintain a hot arch and insure complete combustion.

Ashes are pulled into an industrial car running in the cinder room beneath the stokers and dropped through a grating to the boot of the coal-handling bucket elevator from which they are discharged by means of a transfer valve to a 20-ton ash hopper, and then spouted to cars or wagons.

Located at one end of the power house is a brick stack, 160 ft. in height, with internal base diameter of 9 ft. and top diameter of 6½ ft.

Water Supply

For cooling seven rubber rolls, a considerable quantity of circulating water is drawn from the city main and upon leaving the rolls it is collected in a 6-in. line flowing by gravity to a covered concrete reservoir, 90 by 30 ft. with a 12-ft. depth, adjacent to the power house. As its cooling capacity is dependent upon the outside temperature, the amount of circulating water required in winter does not exceed the amount needed for boiler feed water. In the warmer months, when the amount exceeds the feed water requirements, the surplus overflows to the sewer at the reservoir. All condensation and drips collected in the hot-well are also delivered to this reservoir, from which a 9 by 5 by 12-in. Deane of Holyoke duplex pump raises feed water through a 4-in. line to a Sims open feed-water heater. A similar pump forces the water into a 3½-in. feed main, from which a 2-in. branch extends to each boiler, the pump speed being controlled by a Fisher governor.

Water at 42 lb. pressure for the sprinkler system installed throughout the buildings is supplied continuously by city pressure. In case of fire an 18 by 10 by 12-in. Underwriters fire pump having a capacity of 1000 gal. per min. is connected to the sprinkler system with a flow check. This pump is provided with a safety valve to discharge water into sewer when pressure exceeds 100 lb. Supplying the fire pump is a 12-in. line from the reservoir; in emergency the supply may be taken through an 8-in. line direct from the city main.

Unaflow Engine

Alternating current, at 480 volts, is furnished by a 500-kw., 60-cycle, 3-phase Allis-Chalmers generator, driven at 100 r.p.m. by a 22 and 40 by 42-in. cross compound Allis-Chalmers Corliss engine. To provide for the increasing power demand, a 400-kv.a. Burke alter-

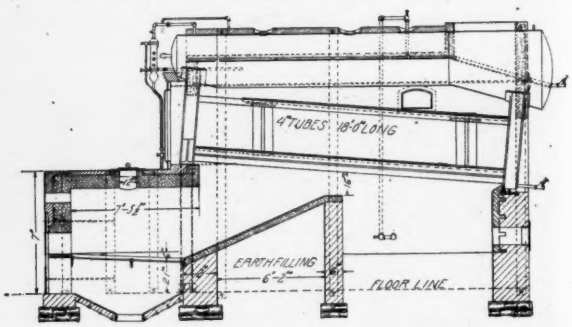


FIG. 3. DESIGN OF WOOD-BURNING FURNACE

nator driven at 200 r.p.m. by a 22 by 21-in. Skinner Unaflow engine was recently installed. Excitation current for each unit is furnished by individual exciters belt connected to the main shafts.

Distribution of the current is effected by a 6-panel marble switchboard—one panel fitted with the necessary current indicating and recording instruments for each of the 2 generators, one panel with recording wattmeters for each of the circuits leading to 3 departments, and a lighting panel. Lighting current is stepped down to 240 volts through a transformer adjacent to the switchboard. A double-throw switch on the panel for the unaflow engine unit makes it possible to supply current to the main bus or to the woodworking shop direct, according to the demand of that department.

The desirability of having recording wattmeters for each main department is evident; it permits an intelligent apportionment of power costs and enables the engineer to locate immediately, and investigate, if necessary, any excessive load conditions.

High and Low Pressure Piping

From the boilers, 7-in. leads are run to a 10-in. boiler room header which connects to the 12-in. engine

room line through a horizontal separator. From the boiler room header a 4-in. branch connected through a pressure reducing valve lowering the pressure from 150 to 100 lb. is run to the shops to supply the blower fans and vulcanizers. Another 4-in. supply line is run to the fire pump and a 2½-in. steam line supplies the feed pumps.

Steam for the Corliss engine is drawn from the engine room header through an 8-in. lead, while the unaflow engine is supplied through a 7-in. line, both lines having long bends.

Exhaust steam from the Corliss engine flows through a 16-in. line in the basement to a cross, from which an 8-in. line extends to the feed-water heater, a 10-in. line runs to the factory, and a 16-in. line is conveyed to an outside riser exhausting to the atmosphere. Tapping into this 16-in. line before it enters the atmospheric exhaust is a 6-in. line extending to the wood drying kilns. In emergency, this line to the kilns may be supplied with live steam passed through a Mason reducing valve.

Under ordinary operation, the exhaust from the unaflow engine is carried through a 10-in. line to a separate atmospheric exhaust. This line passes over, but is connected to, through a gate valve, the 8-in. exhaust line supplying the feed-water heater which it may supply with steam should the Corliss engine not be in operation.

Improved Power Factor

With a load consisting largely of induction motors, many of which carried widely fluctuating loads, a low

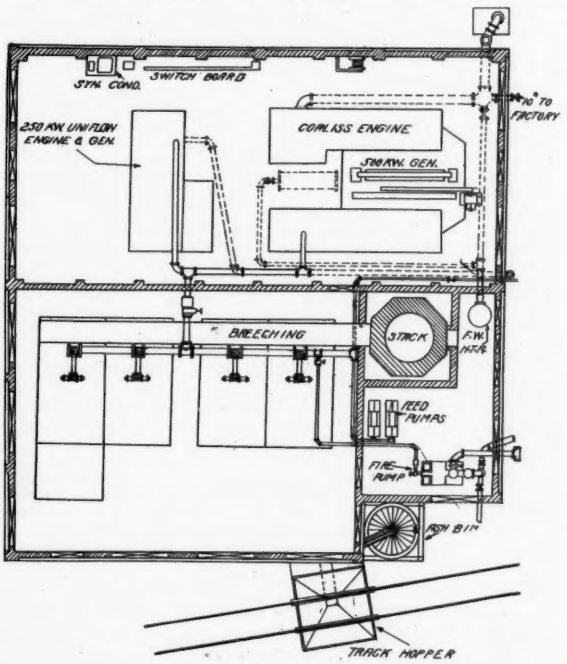


FIG. 4. POWER PLANT ARRANGEMENT

power factor of 0.65 accompanied by its limitation of alternator capacity and other inherent losses was encountered. Synchronous motors or a synchronous condenser offered a logical remedy for this situation.

Obviously, a synchronous motor could not be satisfactorily installed on the rubber rolls, which were the largest and the most effective for this purpose, as it would be pulled out of step by the momentarily high current demand as the wad of rubber entered the roll. It was decided, therefore, to float a synchronous condenser on the line and the 250-kv.a. Burke machine with a 3.5-kw. direct connected exciter and control panel was

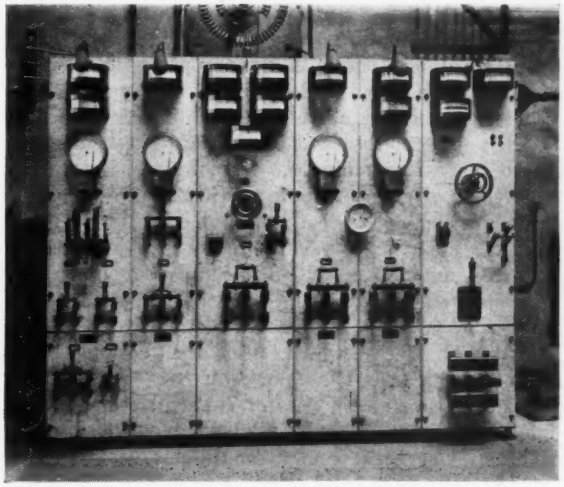


FIG. 5. SWITCHBOARD IN LOVELL PLANT

placed in the engine room near the switchboard. As a result of this installation, the power factor can now be maintained at about 0.95.

Potatoes may be planted up to June 27 with good chance of a large yield. And we shall need every bushel of potatoes that can be produced. By modern methods, such of the crop as is not needed for use as a vegetable can, at moderate cost, be dried as successfully as tomatoes are canned, can be kept indefinitely, and used either as a vegetable or as flour for increasing the supply of bread.

Description of uses of potatoes and their preservation are embodied in a pamphlet which is in preparation by the American Steel & Wire Co. and which can be had free by writing to Dr. H. E. Horton, care of that company, Chicago, Ill.

As a means to helping the shortage of tin it is recommended by Secretary Redfield of the Department of Commerce that fiber containers be used in place of tin cans for packages of non-perishable products such as coffee, tea, tobacco, soap powders, shoe and metal polish, spices, dry foods and chemicals, and the public can help by giving preference to products that are put up in fiber containers. Also buying such foods as baked beans, meat loaves, etc., from delicatessen stores or bake shops, instead of in tin cans, will result in a great economy of tin.

For household use, fiber jars may be used for jellies and preserves and will be found cheap and satisfactory. Information as to where they can be obtained will be furnished on application to the Bureau of Foreign and Domestic Commerce, Washington, D. C.

Tin will be needed in large quantities for preserving fruits and vegetables for next winter's use, in the present campaign for increasing the supply of food and the use of fiber instead of tin, where it will do the purpose will be a bit of service in conserving the resources of the nation at this time, when every bit is needed.

Chain Transmissions

PROPER METHOD OF INSTALLING; OPERATING CONSIDERATIONS. BY J. C. HAWKINS

THERE are many instances where neither belting nor rope drives seem to fill the requirements for the transmission of power. Where the distances between the pulley centers is short, ropes or belts cannot be used to good advantage on account of slippage. Gearing has the disadvantage of fixed centers, noise, friction and lack of flexibility, and a medium of transmission is desired that will combine the elasticity of belts with the positiveness of gears. This condition is met with in the use of link chains.

This system in its various forms is used largely in conveying material as well as the transmission of power. It is positive and there is no chance of slippage, and the only loss of power is in internal friction and that of the links on the wheels which, in a well designed drive, amounts to but from 1 to 3 per cent.

One of the principal uses of chain drives is where a high-speed motor is to be used to drive a slow-speed machine. The shaft center should not be over a few feet, but may be so close that the wheels will just clear.

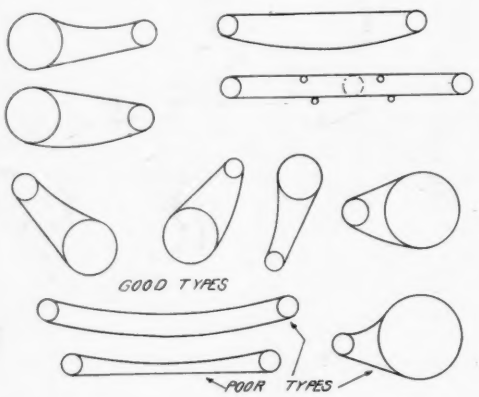
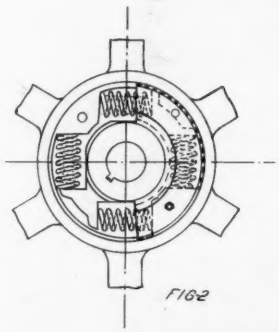


FIG. 1. EXAMPLES OF GOOD AND BAD TYPES OF CHAIN TRANSMISSIONS

This type is applicable only to straight drives, but may be used with good results where the equipment is subjected to dirt and grit as in stoker driving. One place it would seem to give excellent results is in driving the governors on steam engines using type of governor similar to that used on Corliss engines. Here a positive drive is highly essential, and it should be amply strong to guard against breaking which might allow the engine to wreck itself.

The link type of transmission chain may be considered as a flexible rack which has a certain amount of elasticity due to the arch-shaped links, and which to some extent drives through an elastic medium without shock or noise. The pitch of the links is small, being from ½ to 2½ in., giving a large number of teeth in contact with the wheel so that the pressure per tooth is small. They may be operated with the slack on either the top or the bottom, but there are certain practices which should be followed if possible. The sketches in Fig. 1 show good and bad practice. When the small pulley is directly under the large one there should be little slack to prevent the chain from falling away from the teeth on the lower side, and some form of idler should be used unless the centers are adjustable. Where the centers are short and the difference in pulley sizes great, the slack should be on the bottom side to prevent pinching between the teeth on the top side.

Unlike belts and ropes, chain drives are not as readily calculated, and when a drive is desired for any given place all the conditions should be stated to the maker, who will then design a chain to fit the conditions. It is evident that, for a given drive, a chain say ½ in. pitch by 2 in. wide; ⅝ in. pitch by 1½ in. wide, or ¾ in. pitch by 1¼ in. wide could be used to transmit about the same horsepower. The proper speed of this type of chain should be about 1000 to 1300 ft. per min.; a speed as high as 2000 ft. has been used, but is not as a rule recommended. As this drive is not as flexible as belts, there are some instances in which it will cause a severe strain on the chain and machines in starting. This can be reduced by using the spring center wheel shown in Fig. 2. As this type of drive is positive with no chance of slippage, damage may be done if the driven machine becomes stuck; for instance, in a stoker drive in which some part of the machine may become broken. In a case of this



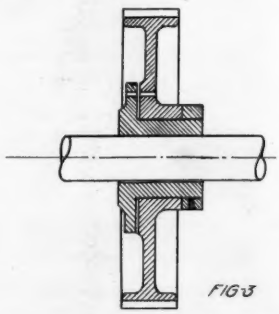


FIG. 2. SPRING CENTER WHEEL

FIG. 3. WHEEL PROVIDED WITH BREAKING PIN

kind, a breaking pin or a weak point is provided which acts as a safety and relieves the strain on the other parts.

Figure 3 shows how this is accomplished. The coupling is in 2 parts, the driven part being turned through the medium of the small pin, which, while strong enough to carry the usual load, will shear off if overloaded. It may be easily replaced. In many cases a common 8-penny wire nail is used.

As this type of drive is frequently used on machine tools and in other places where there is a liability of the workman becoming caught in it, or where grease or other lubricant flying on the floor or other parts of the machine would be objectionable, it should be covered with a guard.

The lubrication of the chain is important and should be done once or twice a week. In some cases it is possible where the chain is fully enclosed to have the lower side dip in an oil bath. For a light chain running in a clean place, a medium grade of machine oil in which a

little flake graphite is mixed, gives good results. For a heavier chain, a heavier oil and graphite should be used. This may be easily applied by means of a paint brush, painting it on the working side of the chain when running slowly so that the centrifugal force will work it into the joints. When the chain becomes stiff and dirty it should be removed and soaked in gasoline and the dirt blown out with an air blast or steam jet. The life of the drive, which is all important, as a rule, judging from the experiences of those who are using them extensively, is from 8 to 10 yr. Considering their 5 to 20 per cent greater efficiency over belts, this makes them economical for places where they are applicable. The life depends, however, on the care with which the drive is designed, the care which it receives while in operation and the conditions of the load.

Charts for Calculating Engine or Turbine Efficiency

THERMAL AND RELATIVE EFFICIENCIES EASILY AND RAPIDLY DETERMINED FROM DATA GIVEN IN PLANT RECORD

TO compute the thermal and relative efficiency of a turbine or engine is a problem we don't enjoy doing frequently, and if not done frequently we get rusty and must review the method every time the problem presents itself. In the operation of a power plant it is of great advantage to know whether or not the prime movers are falling off in efficiency. In many plants a gang of experts is employed continuously for testing the various pieces of apparatus at regular intervals. This is a big expense, but it pays, for any drop in efficiency is noticed and steps are taken immediately to discover the cause and effect a remedy.

It is this need for a quick, ready method of determining the relative efficiency of a steam-driven unit that has led to the development of the accompanying chart, Fig. 2, which has as its basis the heat-entropy diagram so familiar to steam engineers.

Unfortunately the method is not available in all plants, as it requires some method by which the water rate per kilowatt-hour can be estimated. In turbine plants the steam flow meter will give this information and is quite generally employed. Where reciprocating engines are employed, served by surface condensers, a flow meter measuring the condensate will give the amount of water condensed from which the water rate may be secured. When barometric or jet condensers are used the amount of condensate can be estimated if the condensing water is metered or a water weir is used in the hot well by use of the curves shown in Fig. 1.

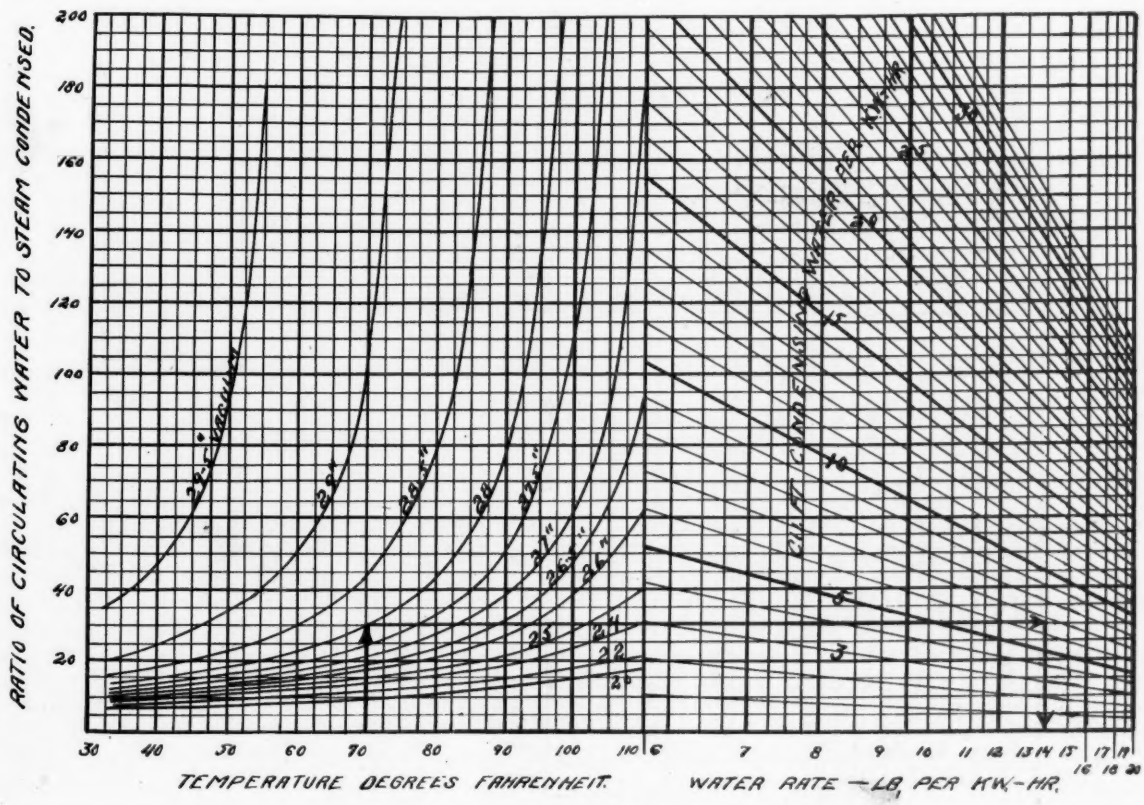


FIG. 1. CONDENSER WATER RATE CHART

The practical application of the chart, Fig. 1, part of which was taken from a bulletin of the Westinghouse Machine Co., is as follows: It will be seen that to produce 28-in. vacuum with 70 deg. cooling water, an ideal condenser requires 30 lb. of water per pound of steam.

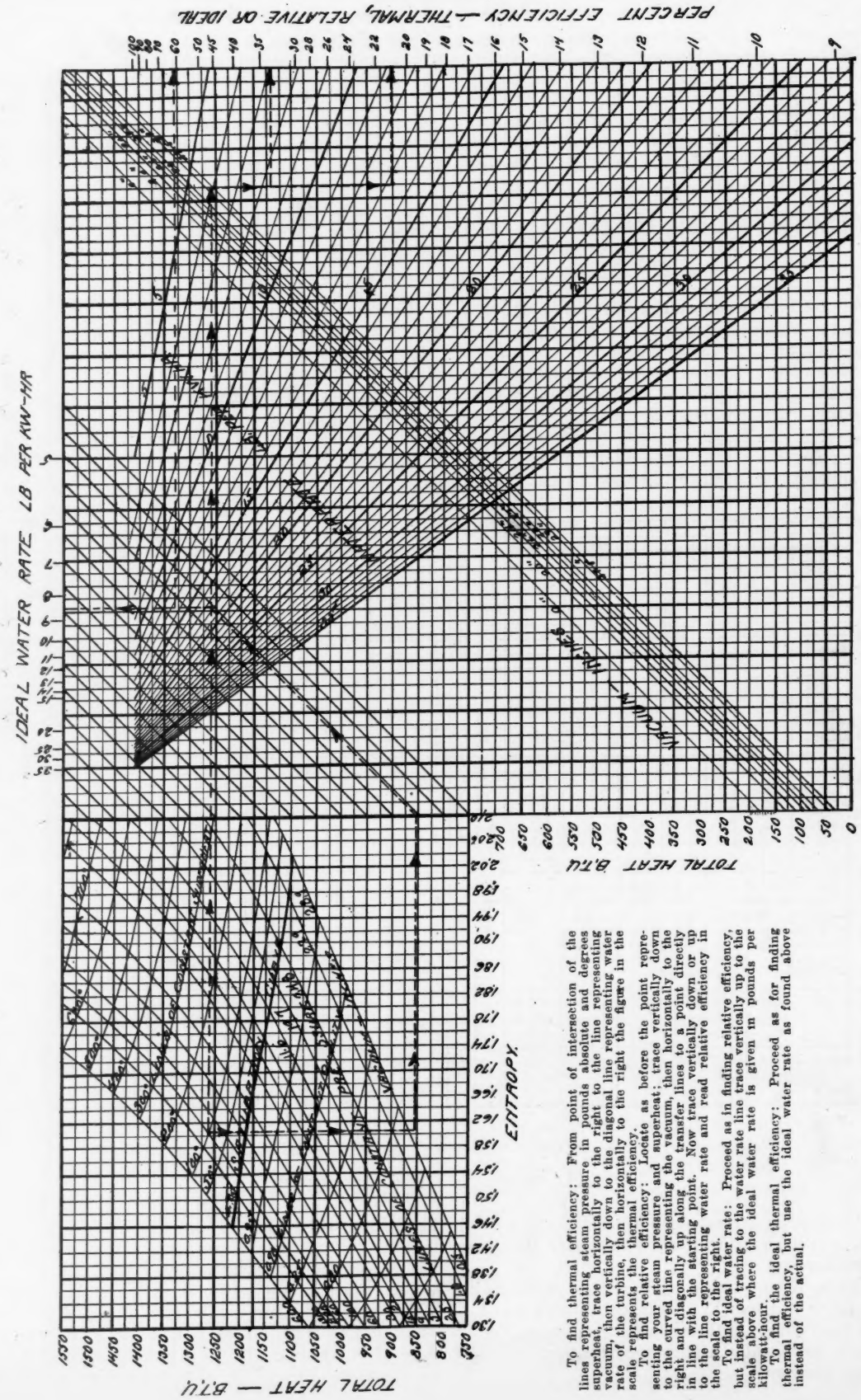


FIG. 2. EFFICIENCY CHART FOR TURBINES AND ENGINES

To find thermal efficiency: From point of intersection of the lines representing steam pressure in pounds absolute and degrees superheat, trace horizontally to the right to the line representing vacuum, then vertically down to the diagonal line representing water rate of the turbine, then horizontally to the right the figure in the scale represents the thermal efficiency.

To find relative efficiency: Locate as before the point representing your steam pressure and superheat; trace vertically down to the curved line representing the vacuum, then horizontally to the right and diagonally up along the transfer lines to a point directly in line with the starting point. Now trace vertically down or up to the line representing water rate and read relative effciency in the scale to the right.

To find ideal water rate: Proceed as in finding relative efficiency, but instead of tracing to the water rate line trace vertically up to the scale above where the ideal water rate is given in pounds per kilowatt-hour.

To find the ideal thermal efficiency: Proceed as for finding thermal efficiency, but use the ideal water rate as found above instead of the actual.

By an ideal condenser is meant one in which the temperature of the condensate and the final temperature of the cooling water is the same, as is the case with a barometric or jet condenser. Under the above conditions, if the generator indicates 1000 kw. and the condensing water meter shows a rate of 6750 cu. ft. per hr., the condensing water used per kilowatt-hour will be $6750 \div 1000 = 6.75$, and the water rate will be found by tracing to the right as shown by the arrow in Fig. 1 to the proper point between diagonals 6 and 7, then down to the scale where we read 14 lb. per kilowatt-hour as the water rate.

By relative efficiency is meant the ratio between the actual and the ideal efficiencies. The ideal efficiency is represented by the Rankine cycle for steam, and the heat convertible by an engine on this cycle is determined by the following formula: $U = H_1 - H_2 + (N_2 - N_1)\ T_2$, in which U is the heat convertible on the Rankine cycle under the given conditions; H_1 is the total heat in 1 lb. of steam at the throttle; H_2 is the total heat in 1 lb. of steam at the terminal pressure; N_2 is the entropy of the steam at the terminal pressure; N_1 is the entropy of the steam at initial pressure and superheat; T_2 is the absolute temperature corresponding to final pressure.

One kilowatt-hour has a heat equivalent of 3412 B.t.u.; dividing this by the water rate will give for 1 lb. of steam the actual British thermal units transformed into electrical energy. Dividing this heat actually converted by the idea heat transfer as found from the above formula will give the relative efficiency.

The thermal efficiency is the output divided by the input. To produce 1 kw.-hr. we must use a certain number of pounds of steam which is called the water rate (W R). The actual heat units used per pound of steam in making this transfer of energy is $H_1 - q_2$, in which H_1 is the total heat in 1 lb. of steam at the throttle and q_2 is the heat of the liquid at the terminal pressure. Expressed as a formula: $E = 3412 \div (H_1 - q_2)\ WR$.

Use of the Chart

By means of the chart, Fig. 2, the relative, ideal and thermal efficiencies can be determined.

To get the thermal efficiency start at the point in the section to the left representing the pressure and superheat of the steam at the throttle, trace horizontally to the right until you meet the diagonal representing the vacuum in inches of mercury carried, then trace vertically up or down to the diagonal representing the water rate which is given in pounds of water per kilowatt-hour of electrical energy generated. Then trace horizontally to the right and read the thermal efficiency.

To get the relative efficiency start at the same point in the total heat entropy diagram, trace horizontally to the right as before, but in this case the diagonal at which to turn represents the total heat in the steam at exhaust. This may be found by tracing from the initial point vertically down to the curve representing the exhaust pressure, then to the right to the total heat axis, and diagonally up and to the right until you reach the horizontal line through the initial point, then vertically up or down to the diagonal representing the water rate of your turbine or engines, turning here and tracing horizontally to the right read the relative efficiency on the scale.

Directions for finding ideal water rate and ideal thermal efficiency are given on the chart. In the problems worked out by the arrows the conditions assumed were: Steam pressure 205 lb. gage, superheat 100 deg. F., vacuum 29.2 in., water rate 13.3 lb. per kw.-hr. The results obtained are: Ideal water rate 8.35 lb. per kw.-hr., thermal efficiency 21 per cent, relative efficiency 63 per cent, and ideal efficiency 33.5 per cent.

Bigger Boilers

Proposed Single Unit to Supply Steam for a 60,000-kw. Turbine

In order to get the greatest economy of space and in use of fuel in large stations where the largest sizes of steam turbines are in use, the question of design of a very large boiler unit was taken up with the Babcock & Wilcox Co. and the details worked out under the supervision of Arthur D. Pratt of that company. The results were stated in a paper before the National Association of Cotton Manufacturers, by John A. Stevens.

This unit would be complete, embodying boiler, superheater, forced and induced draft fan equipment, uptakes, stacks, coal bunkers, ash hoppers and economizers. It consists of four independent sections, any one of which may be operated independently while inspection, cleaning or repairing are going on in the remaining sections, so that it is virtually four boilers arranged as a single unit.

Approximate dimensions are: Grate area, 936 sq. ft.; water heating surface, 57,600 sq. ft.; superheating surface, 14,352 sq. ft.; economized surface, 36,800 sq. ft.; total heating surface, 108,752 sq. ft.

Nominal rating would be 5760 boiler horsepower and actual output at 300 per cent of rating 17,280 boiler horsepower. This general type of boiler has been operated for short periods at 400 per cent of rating, so that 300 per cent operation would be practical.

Using three of the four sections, the boiler could supply steam for a 30,000-kw. turbine and its auxiliaries, and, with four sections operating at 300 per cent rating, it could deliver steam to run a 45,000-kw. turbine unit. For short periods at 400 per cent rating, steam could be supplied for a 60,000-kw. turbine output.

Approximately 10.75 miles of 4-in. tubes would be used for the water-heating surface, and 5.19 miles of 2-in. tubes for the superheating surface. Economizer surface would require 10.64 miles of tubes, making a total tube length for a 4-section unit of 26.58 miles.

Feed water required per hour would be 62,000 gal. at 300 per cent rating or 516,000 lb. and 25 T. of high grade bituminous coal would be burned per hour.

Ground area occupied would be 90.5 by 84.33 ft. including bunkers and firing aisles. The design is such that roofing over the boiler and filling in panel walls between the vertical columns holding the coal bunkers would give a completely housed-in structure. Plans are in progress to show arrangement of a spur track at high elevation to carry the largest steel coal cars above the boilers so that coal could be fed by gravity to the furnaces without rehandling, and similar tracks below the boilers would permit dumping the ashes directly from hoppers to empty coal cars to be hauled away.

Such arrangements would reduce to a minimum the operating and investment expense for the boiler plant, but, of course, they are applicable only to the very largest sizes of central stations.

Test of a 1,000,000-Gallon Motor Driven Centrifugal Pump*

INTERESTING RESULTS OBTAINED AT THE DYERSBURG, TENN., WATER PLANT. BY S. R. BLAKEMAN

IT MAY BE of interest to mention first a few of the characteristics of the plant in which this pump test was made, as well as give a brief outline of the history of the plant and the conditions that necessitated the purchase of the above pumping unit.

The city of Dyersburg, Tenn., owns and operates its own water and light plant, the origin of which dates back to 1903, at which time it was taken over from private ownership. Immediately after the purchase of this plant by the city, steps were taken to improve the plant and distribution system, so as to give good service at minimum cost.

The original design of the plant included 2 10 by 16 by 10¼ by 10-in. Worthington compound pumps, one of these being used to lift water from the wells into the subsiding tanks for treatment, whence it flowed to the filters; the other pump being used to deliver water from the clear well directly into the mains against a pressure of 80 lb. per sq. in. Later, another steam pump was added to the plant, having a capacity of 1,000,000 gal. per 24 hr. This pump was expected to act as an auxiliary for the other pumps.

About the time the last mentioned steam pump was installed, 2 new engines and generators were installed having an aggregate capacity of 435 kw. These replaced the original units, of much smaller size, the load on the station having exceeded their capacity. With the new equipment installed, the plant had to be operated for a large part of the time on very small load, below one-half the rated capacity of the units.

The new engines being of the 4-valve, non-releasing Corliss type, the steam consumption was very high at light loads. The only relief for this condition was additional load, which, of course, could only be obtained from a source outside of the plant and the installation of motor driven pump units in the plant.

A 6-in. motor driven volute pump was installed, to replace one of the 750,000-gal. steam actuated pumps, this pump being designed to deliver 700 g.p.m. against a total head of 45 ft.

Shortly afterward a motor driven triplex boiler feed pump was installed, thereby eliminating the last steam actuated pump in the plant so far as regular operation is concerned.

Each of these pumps is provided with a recording wattmeter. These meters are read every 24 hr., and from this information, the kilowatt-hours consumed by each pump are computed. There is also a recording wattmeter on the switchboard, recording the total output from the generator, the water meter, in the discharge from the turbine pump, giving us the total gallons pumped. All this information, as well as a record of each ton of coal burned, is entered on the log sheet at the plant. From this, the pounds of coal required per kw.-hr. generated, and per 1000 gal. pumped are figured, and properly entered.

An appraisal of the water works and electric light plant was made, from which the amount of fixed charges each carried per 24 hr. was figured. Next, a series of tests were made, extending over a period of more than a week, during which twice the amount of fuel, labor, oil, etc., required to pump 1000 gal. of water was determined; in this data, were also included the kilowatt-hours supplied the volute pump, and also the lime used in the filtration department. After working out the above tests, the average cost of pumping 1000 gal., including capital charges and depreciation on machinery, was found to be $0.064. The average cost of generating a kw.-hr., including capital charges and depreciation, was found to be $0.028. The latter charge had to be determined in order that the cost of operating the motor driven volute could be found.

With all of the above information available, it was at once seen that by the addition of a motor driven pump the economy of the plant could be materially increased. However, before making any final decision it was

TABLE I. CALCULATED DATA ACCEPTANCE TEST OF 1,000,000-GAL. MOTOR DRIVEN CENTRIFUGAL PUMP

TEST NO.	AVE. VOLTS, SECONDARY	AVE. VOLTS, PRIMARY	WATTMETER, TOTAL	WATER, TOTAL	K.W. INPUT	POWER FACTOR	H.P. INPUT	SPEED, R.P.M.	AVERAGE CURRENT	HEAD, FEET	NOZZLE GAUGE, FEET	NOZZLE GAUGE, INCHES	G.P.M.	POUNDS OF WATER	H.P. OUTPUT	MOTOR EFFICIENCY	OVERALL EFFICIENCY	PUMP EFFICIENCY, %	B.H.
1	114.7	2295	127	50300	50.8	0.94	67.5	1710	13.7	119.8	0.95	11.4	1601.2	8343.8	30.3	0.89	0.45	51.1	59.4
2	114.5	2290	125	50000	50.0	0.8[illegible]	66.6	1680	14.3	145	0.92	11.0	913.3	7611.2	33.3	0.88	0.50	56.8	58.6
3	114.5	2290	122.5	49000	49.0	0.89	65.3	1700	13.8	172	0.89	10.7	837.6	6980.0	36.3	0.88	0.55	62.0	57.4
4	114.5	2290	117.5	47000	47.0	0.87	62.6	1700	13.5	190	0.87	10.4	797.2	6643.0	38.2	0.88	0.61	69.3	55.0
5	114.5	2290	112.5	45000	45.0	0.87	60.0	1740	13.0	215	0.82	9.8	686.5	5721.0	37.2	0.88	0.62	70.4	52.8
6	114.5	2290	107.5	43000	43.0	0.86	57.3	1740	12.6	235	0.78	9.3	600.9	5008.0	35.6	0.88	0.62	70.4	50.2
7	114.5	2290	100.0	40000	40.0	0.85	53.3	1738	11.8	259	0.73	8.6	493.7	4114.3	32.3	0.88	0.60	68.1	48.9
8	114.5	2290	97.5	39000	39.0	0.85	52.0	1743	11.5	262	0.70	8.4	451.8	3765.5	29.9	0.88	0.57	64.7	45.7
9	114.5	2290	82.5	33000	33.0	0.79	44.0	1751	10.5	277	0.62	7.4	343.8	2865.0	24.0	0.88	0.50	56.8	38.7
10	114.5	2290	46.0	15475	18.4	0.60	24.5	1740	7.7	254	0	0	0	0	0	0.88	0		21.5

*Size of weir—90° V notch

thought wise to weigh all matters well and see how a triple expansion pumping engine would compare with the motor driven turbine pump; theoretically it was shown that the motor driven pump would effect a saving over the pump then in operation of 511 tons of coal per year, which at $1.75 per ton delivered in the boiler room would amount to an annual saving of $894.25.

While the above showed the theoretical saving that would be effected by this installation, accepting the guarantees on the engines and generators as correct, it does not show the total amount saved, such as oil, maintenance, packing, etc., over the steam actuated pump, nor does it give a fair comparison of the 2 units.

The following formulas will bring out the above more plainly:

$$C = \frac{A \times W \times H \times P}{D} + F\,(i + d) + L + M$$

for the triple expansion pumping engine and

*From a paper read before the American Waterworks Association.

$$C = \frac{A \times W \times H \times K}{2{,}655{,}000 \times \text{overall efficiency of pump and motor}} + F\,(i+d) + L + M$$

for the motor driven pump.

In the above formulas:

C = Total cost of pumping per year.
A = Gallons pumped per year.
W = Weight of a gallon of water.
P = Cost of steam per 1000 lb.
H = Average total head pumped against.
D = Average duty in ft.-lb. per 1000 lb. steam.
F = Total investment.
i = Rate of interest on investment.
d = Rate of depreciation.
M = Yearly cost of miscellaneous expenses of operation.
L = Yearly cost of operating labor.
K = Cost of power per kw.-hr.

Triple expansion pumping engine	*Motor driven turbine pump*
$A = 219{,}000{,}000$ gal.	$A = 219{,}000{,}000$ gal.
$W = 8.33$ lb.	$W = 8.33$ lb.
$H = 175$ ft.	$H = 175$ ft.
$P = 0.175$	$K = 0.02$
$D = 78{,}000{,}000$	$D = 2{,}655{,}000$ ft. lb.
$F = \$5780$	$F = \$1500$
$i = 5$ per cent	$i = 5$ per cent
$d = 5$ per cent	$d = 5$ per cent
$L = \$1200$	$L = \$1000$
$M = \$200$	$M = \$50$

Then the formulas:

$$C = \frac{A \times W \times H \times P}{D} + F\,(i+d) + L + M$$

gives the steam pump,

$$C = \frac{219{,}000{,}000 \times 8.33 \times 175 \times 0.175}{78{,}000{,}000} + \$5780\ (5\% + [5\%) + \$1200 + \$200$$

or $C = \$2694.25$

For the motor driven turbine pump, the formula was used:

$$C = \frac{A \times W \times H \times K}{2{,}655{,}000 \times \text{overall efficiency of pump and motor}} + F\,(i+d) + L + M$$

Then, by substitution,

$$C = \frac{219{,}000{,}000 \times 8.33 \times 175 \times 0.02}{2{,}655{,}000 \times 0.61} + \$1500\ (5\% + [5\%) + \$1000 + \$50$$

or $C = \$1203.94$

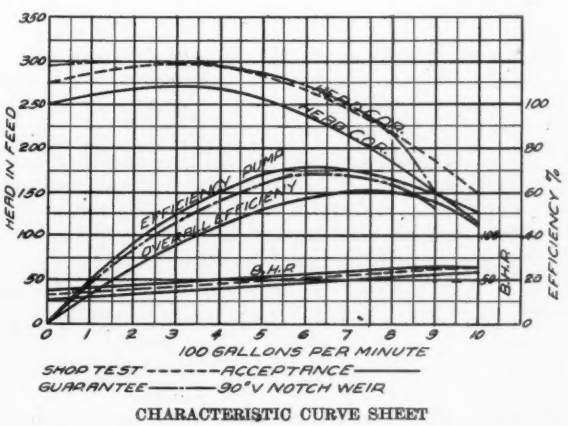
From this it will at once be seen that there would be an annual saving in the cost of pumping by the motor driven turbine pump over the triple expansion pumping engine of $1490.31; this proved that the motor driven turbine pump, everything being considered, would effect the greater saving.

The motor driven pump was installed, and in operation for over a month before the preliminary tests were made. Some trouble was experienced at first with packing, and one of the bearings, which naturally necessitated operating it longer before making the acceptance test than would otherwise have been necessary. Potential transformers on the switchboard were used in the test.

The 2-wattmeter method of measuring the input to the motor was used, as this method would give correct results even with considerable unbalancing in the voltage of the 3 phases. The sum of the 2 wattmeter readings gives the total power in the circuit.

All readings made in this test were made at practically the same time, thereby reducing errors to a minimum. The calculations made, are shown by following through those for test No. 1, on the data sheet shown in Table I.

(1) Average volts secondary	$= \frac{115.5 \text{ and } 114}{2}$	$=$	114.7
(2) Average volts primary	$= 114.7 \times 20$	$=$	2294
(3) Total wattmeter readings	$=$ 86 and 41	$=$	127
(4) Total watts input	$= 127 \times 400$	$=$	50,800
(5) Total kw. input	$= \frac{50{,}800}{1{,}000}$	$=$	50.8
(6) Total hp. input	$= \frac{50.8}{746}$	$=$	67.5
(7) Average current	$= \frac{15.2 \text{ and } 12.3}{2}$	$=$	13.7
(8) Power factor	$= \frac{\text{Watts input}}{\text{Voltage} \times \text{current} \times \sqrt{3}}$		
or power factor	$= \frac{50{,}800}{2294.0 \times 13.7 \times 1.73}$	$=$	0.94
(9) Head in feet	$= 55 \times 2.31$	$=$	127.05
(10) Head corrected	$= 127.05 - 7.23$	$=$	119.8
(11) Hook gage inches	$= 0.95 \times 12$	$=$	11.4
(12) Gallons per minute	$= 0.305\ H^2 \sqrt{H} \times 7.5$		
	$= 0.305 \times (11.4)^2 \sqrt{11.4} \times 7.5$		
	$=$ 1001.2 G.P.M.		
(13) Pounds of water	$= 1001 \times 8.33$	$=$	8,343.3
(14) Horsepower output	$= \frac{8345.3 \times 119.8}{33{,}000}$	$=$	30.3
(15) Efficiency of motor from characteristic		$=$	0.88
(16) Overall efficiency	$= \frac{\text{Horsepower output}}{\text{Horsepower input}}$		
	$= \frac{30.3}{67.5}$	$=$	45%
(17) Brake horsepower	$=$ Efficiency of Motor $\times$ Input		
	$= 0.88 \times 67.5$	$=$	59.4
(18) Efficiency of pump	$= \frac{\text{Overall efficiency}}{\text{Motor efficiency}}$		
	$= \frac{45}{0.88}$	$=$	51%



CHARACTERISTIC CURVE SHEET

On a characteristic curve sheet, 3 different sets of curves are plotted, viz., head-capacity, efficiency and brake horsepower for the guaranteed curves, before

the pump was actually built, the curves obtained on the shop test and the curves obtained from data compiled from the acceptance test. It is interesting to note how the guaranteed characteristics were exceeded, as shown by the efficiency curve, and how close the shop test and acceptance test efficiency curve check.

After these data were worked up and curves were plotted, showing that the guaranteed efficiency had been exceeded, a recommendation was made that the unit be accepted. The writer has never before made an acceptance test where the manufacturers' guarantee was so completely fulfilled as in this test.

Comparative coal tests were made after the acceptance tests had been completed between the steam actuated pump, formerly used, and the turbine pump. The

TABLE II. COMPARATIVE COAL TESTS, STEAM AND CENTRIFUGAL PUMPS

TEST NO.	K.W.H. GENERATED	GALLONS OF WATER PUMPED 24 HOURS	POUNDS OF COAL USED	TONS OF COAL USED	PUMP ON	KIND OF COAL	BOILERS ON	DATE
1	2,360	595,410	19,224	9.61	Centrifugal	Nut, pea and slack	4 and 5	Sept. 29, 1915
2	2,200	584,025	18,690	9.34	Centrifugal	Mine run	4 and 5	Oct. 1, 1915
3	1,690	597,675	21,063	10.54	Steam	Mine run	4 and 5	Oct. 2, 1915
4	2,090	540,225	16,287	8.14	Centrifugal	Mine run	4 and 5	Oct. 3, 1915
5	1,730	526,575	19,788	9.87	Steam	Mine run	4 and 5	Oct. 4, 1915
6	1,640	510,525	25,165	12.58	Steam	Nut, pea and slack	1, 2 and 3	Oct. 13, 1915
7	1,680	546,525	25,365	12.68	Steam	Nut, pea and slack	1, 2 and 3	Oct. 14, 1915
8	2,140	561,975	21,894	10 94	Steam	Mine run	1, 2 and 3	Oct. 12, 1915

results obtained upon this test are shown in Table II. By glancing at these data, the saving in coal between the steam pump and the turbine pump is easily seen.

Since the installation of this pump, it has been possible to cut out one boiler for a great part of the day. It has been in operation for nearly 8 mo., pumping all the water used in Dyersburg, without a single charge for maintenance.

Early Steam Turbine Development Reviewed

AN interesting account of early steam turbine developments at the L Street station of the Edison Electric Illuminating Company of Boston, Mass., was a feature of a hearing before the Massachusetts Gas and Electric Light Commission not long since. C. H. Parker, assistant superintendent of the generating department, occupied the stand. Mr. Parker was called into the hearing to explain an estimate which he had prepared to show the amount which the company was damaged as a result of poor operation of turbines Nos. 3 and 4 (7500-kw. present rating each) soon after these machines were installed. These units were among the earlier equipments of the vertical type and were provided with water and oil step bearings, respectively. When the wheels and diaphragms were being installed on No. 3 unit, a crack was found in the hub of the second stage wheel and a new wheel was supplied. Difficulties arose from unbalancing. In forging the shaft, the metal on one side was harder than on the other and when the shaft was heated a bend resulted. Four different shafts were finally provided for the unit, and the field coils were in part rewound.

For a time it was hoped that the substitution of an oil step bearing for a water step would effect a permanent improvement, but experiments in this direction led to the restoration of the latter. At that time the manufacturer had found that in many turbine plants in other parts of the country if silt or grit was suspended in the water the step bearing and the bottom steady bearing wore out very rapidly. The Boston Edison No. 3 unit had been originally designed for a water step and could not be operated satisfactorily on oil. The temperatures with the water step remained at about city water temperature, whereas in using oil, the repetition of the cycle from the bearing through the piping and tank system back to the bearing gradually led to the heating up of the oil, despite efforts to keep its temperature down by coolers. A temperature of from 170 to 180 deg. was reached at times. This change in temperature seemed to be enough to warp the bottom end of the machine, Mr. Parker stated, so that it threw the steady bearing out of line. He pointed out that unless the 3 bearings are kept absolutely in line, rubbing takes place, with dangerous vibration.

The fourth unit was started with an oil step bearing, and after about 9 weeks' service began to vibrate. New step blocks and guides were then put in. The vibrations ruined the diaphragm packings, which were designed to prevent leakage of steam from one stage to the next. Later, for uniformity in the system, this unit was changed to a water step, and it has been found that Boston metropolitan water is sufficiently clean to avoid the troubles experienced in the lubrication of water step bearings in some western stations.

Mr. Parker said that the third and fourth turbines were newer and had a much better water rate than the first 2 machines installed at L Street. Due to their not being in condition, it was necessary to run the old machines at a loss of 4.1 lb. of steam per kilowatt-hour. Units 1 and 2 (5000-kilowatts each) took about 18.02 lb. of steam, and units 3 and 4 took 13.9 lb. On this account an estimate was made of the total increased coal consumption arising from the initially unsatisfactory service of the third and fourth units; this totaled about $23,000 for a period of about 2.25 yr. on No. 3 units and about 6 weeks on No. 4. The hours when these units were actually used on the system in the production of commercial energy were not included in the computation. Later computations brought the total estimated increased coal consumption for a more extended period to $42,267, and the witness said that he included $10,000 for general expense at the close of the calculations, as No. 3 machine was at that time of no use to the operating company. It was necessary repeatedly to start it and run the auxiliaries to enable the manufacturers to study the balancing problem, to make tests, etc., and the station staff of the Edison company was ordered to keep track of the hours of starting and stopping the auxiliaries and the turbine itself. The machines were finally satisfactory, and a compromise settlement by the manufacturer was made, according to other testimony, at $19,180. The witness said that at one time the turbine manufacturer proposed the assignment of certain boilers to the turbine under investigation for exclusive use, dissipating the energy produced

in a water rheostat, but this plan was never carried out on account of the cost, which was figured at $298 per day.

Questioned as to the comparative economy of turbines and reciprocating engines, Mr. Parker said that the water rate of the so-called 4-1 section of the L Street station, containing 6 1500-kw. engine-driven alternators, was 17 or 18 lb. per kw.-hr., whereas the turbine station (so-called 4-2 section) is now running at between 13 and 14 lb. The whole six engines in the older section of the plant took seven oilers per watch for 9000 kw., and a 12,000 or 15,000-kw. turbine, with all its auxiliaries, takes but one oiler. Three firemen are required for a 12,000-kw. turbine compared with 11 firemen in the 9000-kw. engine plant. Mechanical stokers, however, were figured in the former case against hand firing in the latter, with the ash pits on the floor levels. The witness said that in turbine repair work, the manufacturer's experts are always called upon by preference, in view of their experience under varied conditions as specialists.

Luxury Coal

SPEAKING of conservation of our coal resources, Francis S. Peabody, chairman of the Coal Board of the Council of National Defense, appeals for care in the use of coal by all the people of the country, so that there may be, at all times, sufficient supply for battleships and for manufacture and transportation of materials needed for war purposes.

"It is not that we do not have the coal in this country, but it is a question of digging it out of the ground fast enough and having prompt deliveries by the railroads at the places where it is most needed.

"The less coal the householder uses, therefore, the more there will be for the essential industries, the men of which in this industrial war are all soldiers as much as the man who wears a uniform and marches to the front.

"But the householder asks where he comes in. In the first place, in many homes throughout the country he can maintain a less number of coal fires. He can even shorten the number of hours they are in operation. He can see that gas stoves are turned off as soon as the cooking is over. When the weather is cool, he can carry lower temperatures in his home than he has been accustomed to, unless there is illness in the house. A temperature of 60 deg. instead of 70 is sufficient. Then he can operate fewer gas and electric lights and see that they are turned off when not needed or when he leaves the room. This also will reduce the living costs of the family appreciably.

"And this leads to the suggestion that, if ever there were need for the introduction of the proposed daylight-saving act throughout the country, it is now. Begin work an hour earlier and quit an hour earlier. That immediately would take an hour's burden from the electric light companies and the electric power companies. People would be sleeping instead of using lights generated by coal. In compact little England, with daylight saving, they have saved 300,000 tons of coal in a year's time.

"In time of war, the coal wasted in this manner is 'luxury' coal, and that leads to the thought that Americans are the greatest advertisers in the world with their brilliantly lighted downtown sections of great cities; the mammoth electric advertising signs blazing for miles, and their elaborate 'White Cities,' their Coney Islands and their 'Dreamlands.' It is all very well to be up and doing and pushing your product in a big way in peace times, reflecting much enterprise upon American methods of doing business. But in war time, doesn't all this tremendous expenditure of energy from coal mean the use of 'luxury' coal which ought to be stopped from a pure spirit of patriotism?

"For the time being, let's save this 'luxury' coal that goes into amusements and extravagances and frivolities. Some American merchants may call this sacrifice, but anyhow we all have to make sacrifices in times like these, and as soon as the country fully realizes this spirit, that moment we go forward to decisive and prompt victory.

"To the manufacturer I would say that it is the time to pay a little more attention to your boiler room and see what becomes of the coal. Time was, in this country, that coal was so cheap and entered so little into the cost of manufacture that few cared how the coal was burned. Since that time, we have made tremendous progress in the science of combustion, until today, black smoke pouring out of a factory chimney is not a badge of prosperity but a badge of inefficiency and of waste. To get power out of coal you have to burn it, and letting it go up the stack in smoke is not burning it. Any mechanical engineer today can show how."

ONE OF the mediums for assisting the conduct of the present war, in which every citizen can take part, is the Navy League of the United States, whose offices are located in the Southern Building, Washington, D. C., A. H. Dadnum, Secretary. The work of the League in the past entitles it to careful consideration.

Through its efforts was it possible to secure the provision, made by the last Congress, for adequate appropriations to increase ships of the navy, and its influence has been helpful in building up the recruiting for the navy to the present number of more than 100,000 enlisted men. Its work is, however, just well begun now, and everyone who is in position to do so can help.

The objects of the League are to aid in recruiting for the naval service, to assist in procuring enrollments in the Naval Reserve, to assist in securing the passage of necessary bills for the improvement of the Navy equipment and Navy service, and to undertake to furnish needed articles of clothing, equipment and hospital stores required by the Navy service and not now furnished by the government.

It has, also, a home service for the relief of the families and dependents of men of the Navy and Marine Corps, where such families are not provided for by the government.

The League is working in co-operation with the officials of the Navy Department, and has their hearty approval. Local branches of the League are being formed in many towns and cities throughout the country, and also individual members of the League can help, both by joining and by taking active part in the objects as above outlined. Full information in regard to either personal membership or the forming of local branches can be obtained from the headquarters of the League.

Electrical Machinery and Appliances

For Generating, Transmitting and Using Current

Interpole Motors

DISCUSSION OF ARMATURE REACTION AND THE USE OF COMMUTATING OR REGULATING POLES. BY GORDON FOX

INASMUCH as the use of interpoles, otherwise termed commutating or regulating poles, is becoming extensive in direct-current motor design, an understanding of their principle of action is desirable. The functions of the interpole may be best understood if the action of commutation is briefly reviewed. The purpose of a commutator is to conduct uni-directional current to and from coils passing under alternate north and south poles, and having generated in them alternating voltages. When these coils are directly under the main poles they

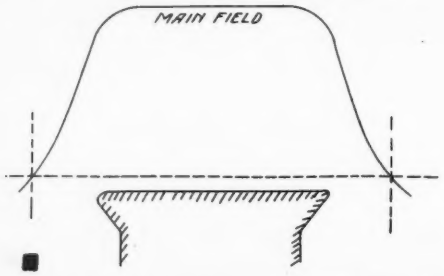


FIG. 1. FIELD FLUX DISTRIBUTION OF UNLOADED MOTOR

cut the most flux and the voltage per coil is at its maximum. When a coil is midway between poles, the voltage passes through zero and changes sign. The brushes bearing upon a commutator must have appreciable width, hence must span at least two commutator bars, short-circuiting them. If a brush were so located that it spanned bars connected to coils in a strong field the resulting short-circuit current would be very great. On the other hand, a brush spanning bars connected to

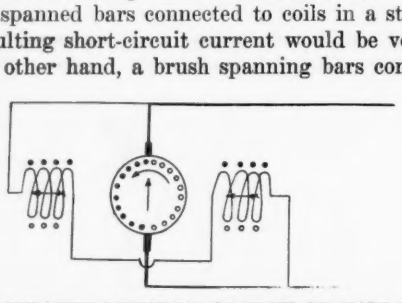


FIG. 2. RELATIVE DIRECTION OF FLUX OF MAIN FIELD AND THAT DUE TO FLUX OF ARMATURE CURRENT

coils passing through zero voltage carries but little current. It is thus desirable that motor brushes be located in a neutral zone in which there is little or no voltage between commutator bars.

When an ordinary direct-current motor is operated without load with the brushes resting upon commutator bars connected to coils located midway between poles, the flux distribution is as in Fig. 1. When a load is placed upon the motor the armature current increases. This current flowing through the armature conductors has a magnetizing influence in a direction 90 electrical degrees from that of the main field. This armature magnetizing influence is therefore called a cross field and its origin is made plain by Fig. 2. This cross field, in combination with the main field, causes the main flux to be crowded to one side of the main poles and into the air gap. The conditions now prevailing in the motor are shown by the resultant field form of Fig. 3.

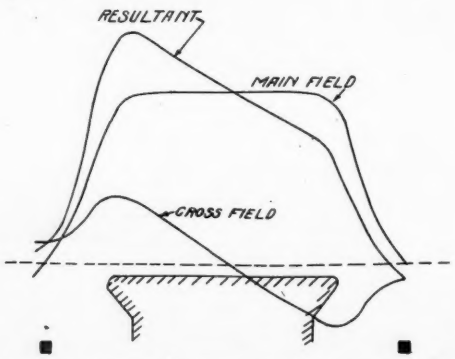


FIG. 3. RESULTANT FLUX DUE TO MAIN FIELD AND CROSS FIELD CREATED BY ARMATURE CURRENT

It will here be seen that, due to the crowding influence of the cross field or armature reaction, the neutral zone has been shifted in a direction against the rotation of the motor. In order that the brushes may now be located in the neutral zone, it is necessary that they be shifted. Shifting the brushes changes the axis of the cross field

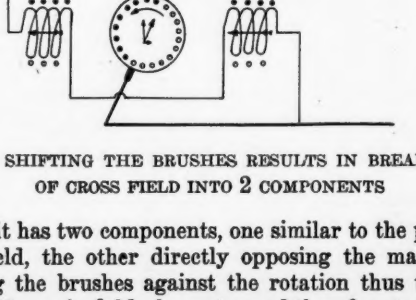


FIG. 4. SHIFTING THE BRUSHES RESULTS IN BREAKING UP OF CROSS FIELD INTO 2 COMPONENTS

so that it has two components, one similar to the previous cross field, the other directly opposing the main field. Shifting the brushes against the rotation thus tends to weaken the main field of a motor and therefore to increase

its speed. The conditions now existing in the motor are shown by Fig. 4 and the flux distribution by Fig. 5.

The direction of the cross field of a motor depends upon the brush position; its magnitude depends upon the armature current. The armature current depends upon the load. The amount of field distortion and neutral shift are thus directly dependent upon the motor load. Since the motor brushes remain fixed they can be located correctly for a single neutral position only, corresponding to a given load current. With any other load the brushes are necessarily slightly displaced from the neutral position and are in a zone in which there is some voltage between adjacent commutator bars spanned by a brush. In consequence of this voltage difference, local short-circuit currents flow across the brush face. These short-circuit currents, superimposed upon the work current, cause high current density along the trailing edge of the brush. The sudden interruption of this current causes arcing and spitting as the commutator bar passes out from under the brush.

The current in the armature of a direct-current motor or generator is continually reversing. Each commutator bar passes alternately under brushes of opposite sign so that the current goes into or out of that bar alternately. A change of current in a coil causes an inductive kick, and the change of current intensity causes a self-induced voltage in the short-circuited coil under the brush. This self-induced voltage opposes the change in current value and sign and tends to maintain the current in the direction in which it was previously flowing. This energy, stored through inductance, is dissipated in a discharge through the short-circuited coil and brushes, causing sparking. The effect is most marked in the case of high-voltage armatures having a large number of turns in each coil with consequent large inductance. In order to counteract this self-induced voltage in the short-circuited coils the voltage in those coils should be enabled to drop to zero and be built up in the changed polarity to help the change in current direction while the coil under the brushes is in mid-position. In order to accomplish this in an ordinary motor it is necessary to increase the brush shift against the rotation so that the commutated coils come under the influence of the trailing pole tip and have generated in them a slight counter voltage which will aid the reversal of current flow and reduce the inductive kick.

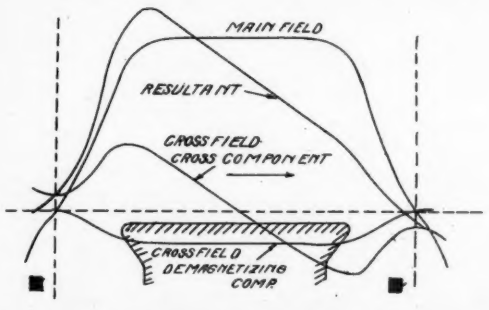


FIG. 5. RESULTANT DISTRIBUTION OF FIELD FLUX DUE TO SHIFTING OF BRUSHES OPPOSITE TO DIRECTION OF ROTATION

Armature reaction and coil inductance are similar in their effect. It is thus fortunately possible to overcome both by a single means. The introduction of a narrow interpole midway between main poles makes it possible, first, to prevent the shifting of the neutral position under the brushes with every change of load by introducing a proportionate counter action; second, to create a small flux in the neutral zone just sufficient to generate in the short-circuited brushes a small voltage favorable to current reversal in order to overcome armature self-induction effects.

The influence of the interpole may be seen by inspection of Fig. 6 showing the flux distribution in an interpole motor under load. It will be seen how the interpole field neutralizes a portion of the crowded main field in the neutral zone and still has a slight excess of magnetizing force to create a field to aid current reversal. It should be noted that the influence of the interpole is limited to a comparatively narrow zone immediately under the auxiliary pole.

Since the function of the interpole is to neutralize the influence of the armature cross field upon the commutated coils its effect must be proportionate to that of the armature. This is secured by connection of the interpole windings in series with the armature. The iron of the interpoles is normally worked at a low degree of saturation so that the magnetizing effect is almost directly proportionate to the magnetizing force. With this arrangement, the interpole flux and cross flux practically neutralize each other at all normal loads regardless of the strength of the main fields. The shifting tendency being overcome, the neutral position remains fixed at the no-load neutral or central position independent of load changes. With very heavy loads the interpole may become saturated; but, since the main pole tips and the armature iron are also saturated under such conditions, the shifting tendency is lessened.

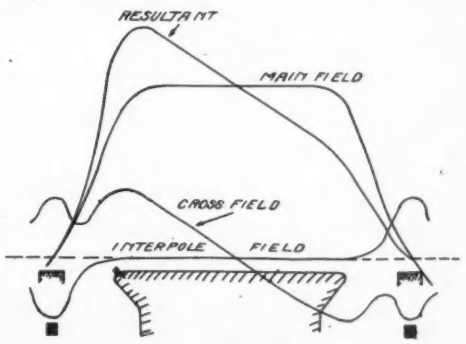


FIG. 6. RESULTANT FIELD DUE TO INFLUENCE OF INTERPOLE

It is evident that a definite polarity relation must exist between main pole windings and interpole windings in order that correct action in aiding current reversal may be obtained. The current in the armature of a generator flows as a result of generated pressure. A coil leaving a north pole must enter the zone of a south pole to cause reversal of current. Therefore the interpoles of a generator are of the same sign as the next following pole in the direction of rotation. The interpole acts here as sort of an advance pole to reverse the current and build it up before the coil enters the field from the main pole.

In the case of a motor conditions differ, the armature current here flowing in opposition to the generated pres-

sure. The main field magnetism itself is always acting to stop the flow of current by building up a counter voltage. Therefore the effect of the main field must be carried over to the interpole zone to there cause the current to fall, reverse and build up in the opposite direction. The interpoles of a motor are thus of the same polarity as the preceding main poles in a direction against the rotation. This can be viewed in a different manner. In a shunt motor we shift the brushes against the rotation to bring the commutated coil into the field of the preceding main pole against rotation. To avoid this shift, we must bring the preceding pole's field toward the commutated coil by making the following interpole of the same polarity. Likewise, in a generator, the brushes are

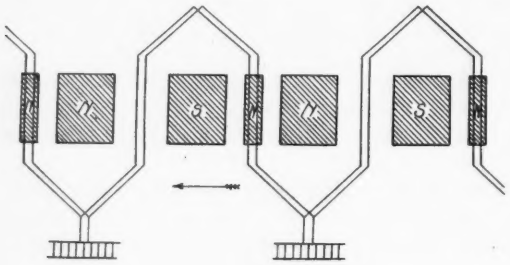


FIG. 7. SOME MACHINES ARE PROVIDED WITH BUT HALF AS MANY INTERPOLES AS MAIN POLES

shifted with rotation to improve commutation by bringing the commuted coil under the influence of the following pole. Therefore the interpole is rightly of the same polarity as the pole following with the rotation. In a motor, the brushes are shifted against rotation and polarity of interpoles is the same as that of the preceding pole against rotation.

The number of interpoles placed in a machine is a matter of design, depending upon the armature coil throw, available space and other factors. There may be as many interpoles as there are main poles, or there may be half that number. The action is the same in either

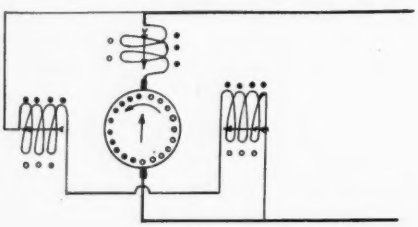


FIG. 8. MAGNETIZING FORCES IN A MOTOR HAVING BOTH INTERPOLE AND COMPENSATING WINDINGS

case. The reason may be best illustrated in connection with Fig. 7. This figure shows interpoles in alternate spaces only. The coils under commutation are shown diagrammatically and it will be noted that one side of each of these coils is under the influence of an interpole. The idea is to generate all the commutating counter voltage in one side of the coil instead of jointly in two sides, as in the case where there are as many interpoles as main poles. Where only half the number of interpoles are used, they must be provided with more ampere turns per pole. It should be noticed that with the arrangement shown all the interpoles are of like polarity.

It was pointed out in a previous paragraph in connection with the discussion of Fig. 6 that the influence of the interpole is confined to a narrow zone immediately under it. It is sometimes desired to counterbalance more completely the influence of the armature cross field and to prevent its distorting action upon the main field at all points, rather than merely in the neutral zone. This is accomplished through the addition of a so-called compensating winding having an action similar to that of the interpole but distributed over a wider arc. The compensating winding is inserted in slots in the main pole pieces. Its magnetizing influence is along the same axis as that of the interpole and in opposition to the cross field of the armature. The interpole field neutralizes the cross field only directly under the interpole face; but the compensating field, being distributed directly opposite the armature conductors causing the cross field, is able to counteract it altogether and thus prevent all field distortion. Figure 8 shows the different magnetizing forces in a motor having both interpole and compensating windings, and Fig. 9 shows how the various fields are distributed and how they combine to produce a practically undistorted main field. Compensating windings are used on direct-current machines only in connection with interpoles, the latter providing the neutralizing influence in

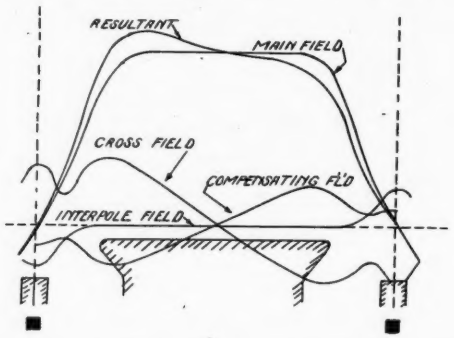


FIG. 9. COMBINED FIELDS PRODUCE A PRACTICALLY UNDISTORTED RESULTANT

the neutral zone and furnishing the necessary reversing field. Interpoles used in connection with compensating windings are made weaker than when used alone because the presence of the compensating winding lessens the work required of the interpole.

Measuring Root-Mean-Square Current

IT IS well known that the continuous capacity of any piece of electrical apparatus is limited by the amount of heat it can dissipate. In most electrical apparatus the principal sources of internal heat are the copper and iron losses. The rise in temperature is approximately proportional to the square of the current passing through the machine. On variable load this rise is proportional to the average of the squares of the current values during the cycle of operation, or what is called the "mean-square current." There is a certain value of this mean-square current at which each machine will operate most economically. If operated at a higher value it is liable to become unduly hot, resulting in short life

of insulation and consequently requiring expensive repairs. If operated at a lower value its efficiency is reduced, its size is larger than necessary and, in the case of a railway or other vehicle motor, excess weight is being carried.

The problem of efficient operation, therefore, resolves itself into a determination of the mean-square current required to move the load at the desired speed, and applying the machine that operates at this current most efficiently. For this purpose it is often necessary to make a test on existing apparatus in the field. For convenience in computing, the square root of the mean-square-current value is generally determined in the tests. Many

FIG. 1. WESTINGHOUSE ROOT-MEAN-SQUARE CURRENT METER AND DIRECT-CURRENT SHUNT

electrical machines, such as railway motors, are rated by this root-mean-square current.

Determination of the root-mean-square current of a machine in actual service where instantaneous current values are changing rapidly (variable load), and especially in railway service where the car or locomotive is in motion, has heretofore been a tedious and expensive undertaking. The root-mean-square current is obviously the square root of the average square of the instantaneous current values taken at infinitely short intervals during a given period of time. The longer these intervals the more inaccurate will be the results, especially under rapidly changing current conditions. Hence, in determining this value by actual test, it is necessary to take current readings as frequently as possible, equal time intervals usually being most convenient.

To facilitate making tests for root-mean-square current, the Westinghouse Electric & Manufacturing Co. has developed the root-mean-square current meter, Fig. 1. The measurement by this meter of the root-mean-square value of the current depends upon the generation of heat, by passing all or part of the current to be measured through resistance immersed in a given quantity of distilled water. The temperature of the water is therefore raised in proportion to the square of the current flowing through the resistance element. It is very evident therefore that the square of each instantaneous current is virtually integrated by the raising temperature of the water due to the heat taken up by it. Radiation of this heat to the surrounding atmosphere is prevented by the use of a vacuum jar. As the temperature of the water near the top, if let stand, would be slightly higher than that near the bottom, a means is supplied for thoroughly mixing the water just before taking the temperature reading.

To determine the root-mean-square current value with this meter in the circuit, it is only necessary to observe the elapsed time and the rise in temperature of the water. By applying these values to a calibration curve, Fig. 2, furnished with the meter, the root-mean-square current value can be determined very rapidly. Simultaneous readings of water temperature and time of day are generally taken at half-hour intervals. In tests of railway equipments these readings can be taken at such points as will facilitate the determination of the root-mean-square-current value for each section of the run.

By the use of this meter the number of observers on the test is reduced to a minimum as only a few minutes of one observer's time is required during each observation period. The results can be approximated readily while the test is proceeding. For an all-day test, a very short time is required to determine from the test data the root-mean-square-current value for each intermediate period and also for the entire day; with the very frequent readings necessary by the older method, to obtain the same amount of data, several days' computing was necessary. Furthermore, with this meter the

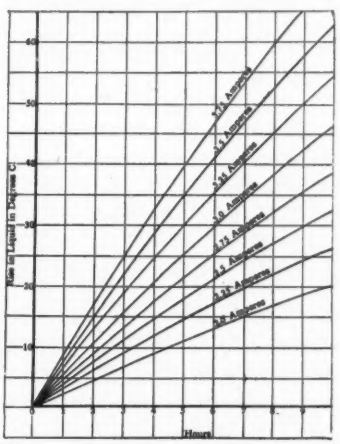


FIG. 2. TIME TEMPERATURE CURVES TO BE USED IN CONNECTION WITH WESTINGHOUSE ROOT-MEAN-SQUARE CURRENT METER

personal error in rapidly taking readings is reduced to a minimum. It is claimed by the manufacturer that careful laboratory tests with the meter on constant current values and on all kinds of rapidly fluctuating current values, show it to be correct to within 2 per cent.

The meter can be used with accuracy on either direct or alternating-current capacity being supplied for use on direct current and a current transformer for alternating-current circuits.

Lubrication of Diesel Engines

PROPER SELECTION, APPLICATION AND CARE OF OILS AND OILING EQUIPMENT. BY R. C. DE MARY

LUBRICATING conditions which are met with in the operation of Diesel engines are much more severe than with steam.

A suitable lubricant for the former must have the three following requirements:

First—It must lubricate the piston in an efficient manner at the high temperatures encountered.

Second—It must seal the piston and rings to prevent leakage.

Third—It must burn without forming carbon in the cylinder.

The first requirement is an important one and depends on the viscosity or, in other words, its resistance to flow. The higher the viscosity the less fluid the oil, and this property decreases greatly as the temperature increases. Viscosity is generally expressed as light, medium, heavy, etc., though the viscosity of light, medium and heavy oils may vary with different brands. For instance, two light oils of different brands may differ greatly in viscosity.

The action of heat on oils is determined by the flash point and the fire point. The flash point is the temperature to which the oil must be heated in order that the vapors given off will make a slight explosion when a flame is held directly over the oil. The fire point is the temperature to which the oil must be heated so that it will take fire, and continue to burn after a flame has been applied. The fire point is from 40 to 50 deg. F. above the flash point.

Practically every oil used on Diesel engines has a flash point above 320 deg. F., and if the temperature rises above that there is something wrong, not with the oil, but with the engine. Locate the trouble, and remedy it, but do not feed more oil or change lubricants.

Lubricating oil does not burn readily, and furthermore the time given it in the cylinder is very short. An engine running at only 100 r.p.m. would expose the lubricated surface of the cylinder to the action of the flame for less than one-quarter of a second. At higher speeds the time allowed for the oil to burn is so short that a flash point of as low as 300 deg. F. would be sufficiently high for any Diesel engine, except in the most unusual conditions.

The chief trouble maker in connection with the operation of Diesel engines seems to be carbon deposits in the cylinder. The lubricating oil, of course, is blamed for this, when in nine cases out of ten, it is the operator, or in other words, a little more care and reasoning would prevent shut-downs.

Carbon exists in two forms: First, fine carbon suspended in the oil, and, second, in combinations forming hydrocarbon compounds which go to make up the oil. The amount of fine carbon is very small and the trouble from this cause in most cases is due to some other factor.

I have found, in nearly every case where trouble was caused by carbon, that the engineer was using more oil than was necessary for proper lubrication. An over supply of oil in the cylinders will always cause the formation of carbon. Use an oil with an asphalt base and not too heavy.

The addition of a small amount of graphite (about one teaspoonful to one gallon of oil) will assist in the lubrication, and also, I have found, will, to quite an extent, assist in preventing carbon deposits. The amount of oil necessary to lubricate the cylinders of a Diesel engine depends on so many factors that it is necessary to solve the problem for each individual engine.

Oils made from the asphalt-base crudes of the southern states are much superior to any others for Diesel lubrication. Those oils having a paraffine base, such as the Pennsylvania crudes, have a very low viscosity, and to remedy this it becomes necessary to resort to compounding. The light oils are mixed with the heavier cylinder oils, and the latter is responsible for most of the gumming and carbon troubles due to lubrication. The asphalt-base oils are composed chiefly of the ethylene and the napthene series and distil without decomposition. No gum will be found in the cylinders or in the valves, and the fine carbon will nearly all be discharged through the exhaust.

The color of an oil, regardless of what the manufacturers claim, has no relation to its lubricating value. You can, however, tell if the oil is compounded with the heavy cylinder oils, for the reason that it will always show the green tinge of the latter.

While every Diesel engine is equipped with a force feed lubricator, I regret to say that many of them are of little use. I am not connected in any way with the manufacture or sale of lubricators for Diesel engines, but to my knowledge there is but one which I consider suitable for that purpose. This lubricator is driven by a lay shaft and is so adjusted that the pump plunger work is in synchronism with the pistons. The oil is delivered directly onto the pistons, between the rings and at the end of the stroke. Now if we consider for a moment we can see how important such a method is. The oil that does not strike the piston or is forced into the cylinder at such a time as the oil hole is uncovered by the piston is wasted and means just so much more carbon forming material.

The amount of oil required to lubricate the cylinders of a Diesel engine properly naturally depends upon several factors. The most important ones are design, style of lubricator and quality of oil. I have found that where an engine is well designed, and the temperature of the cooling water as it comes from the cylinders is not above 176 deg. F., I obtain best results on a feed of 18 to 20 drops of oil per minute, per cylinder, where the size is not above 16 in. in diameter and 25-in. stroke. This amount of oil I would consider about right for all dimensions below those given, and where the revolutions do not exceed 160 per minute. Where the bore is from 16 in. to 25 in. and the stroke 25 in. to 32 in., the average amount of oil is 25 drops per minute. With engines of this size the speed is naturally less, and the amount of oil is somewhat lower in proportion. These are average cases. Under some conditions I have found I could reduce the amount of oil mentioned and in others it was more than double the amount given above. The excessive requirement was due to poor rings, that is rings

which leaked badly, and an extra amount of oil was required to maintain a seal between the rings and the cylinder in order to keep up the compression. Where the lubricator is one that feeds the oil in synchronism with the engine piston, the amount of oil may in most cases be reduced a few drops per minute. If on removing a cylinder head a film of oil is found on the walls of the cylinder sufficiently thick to penetrate two thicknesses of cigarette paper, you will know you are getting a sufficient amount of lubricant.

Beware of whom you buy your oils and be sure they contain no animal fats. Under ordinary working conditions an oil with a viscosity of not less than 200 at 100 deg. F. and a low cold test is recommended. If your engine is subject to overload, or is so located that the temperature of the room is high, a heavier oil should be used, one with a viscosity of from 300 to 400 and a low cold test. Sometimes the working conditions are very severe, and trouble is experienced from leaky rings and an oil with a viscosity of as high as 600 to 650 may be necessary.

Remember the color of the oil means nothing, neither does the density as a specific property, for when we mention light, medium or heavy, we are concerned only as to viscosity. Light means low viscosity and heavy means high viscosity. Excessive friction may result from either too high or too low a viscosity. Too high a viscosity will give a good film oil, yet the friction in itself will be excessive. If the viscosity is too low the film will be broken. Get just as thin a film of oil as you can, yet have it perfect, and you have solved the lubrication problem.

All the oil should be filtered before using. This may seem needless with new oil, but even under the best conditions foreign matter will sometimes get into the lubricant and, if filtered, this will be removed and be the means of preventing a serious shut-down.

Where the engine has an enclosed crank case and uses the splash system on the bearings, the oil should be renewed frequently and filtered. The oil may seem to be in good condition, but you will be surprised at the amount of sediment it contains and which may prove detrimental to the bearings.

The appreciation of the foregoing principles should enable anyone to obtain an oil suitable for his engine, and to use it in such a manner as to obtain the best results. I also believe that trouble due to carbon can be almost entirely eliminated by a study of its causes, and the use of a little judgment.—The Gas Engine.

U. S. Civil Service Commission announces an examination for aeronautic draftsman. Three vacancies in the Bureau of Construction and Repair, Navy Department, at $4 to $5.04 a day, and future vacancies requiring similar qualifications in the department at Washington, D. C., or at any navy yard or other naval establishment, will be filled from this examination. Duties will consist in preparing notes and recommendations, checking plans and specifications, making sketches, designs, and drawings, in connection with sea planes and dirigibles. Competitors will be rated on general education, technical training and practical experience. Applicants must have reached their twentieth birthday on the date of making oath to the application. Until further notice, applications will be received at any time. Apply for Form 1312.

Losses Indicated by Carbon Monoxide in Flue Gases*

By W. F. Schaphorst

IN the Practical Reference Tables of this issue is a chart which gives the fuel loss indicated by too much carbon monoxide in the flue gases. To determine the loss no figuring is necessary. Just zigzag a straightedge across the chart three times as indicated by the dotted lines and column G immediately gives the per cent of fuel loss.

For example, a given coal contains 70 per cent of carbon; the flue gas contains 10 per cent carbon dioxide (CO_2) and 1 per cent carbon monoxide (CO); the heat value of the coal is 12,000 B.t.u. per lb. What is the fuel loss?

Run a line through the 70 (column A) and the sum of $CO_2 + CO$ (column B) and locate the intersection with column C. From that located point run through the 1 (column D) and locate the intersection in column E. From that point run through the 12,000 (column F) and the intersection with column A shows the answer—5.4 per cent.

The range of the chart is wide enough to take care of nearly every condition of flue gases. Should the intersections with column C or E fall "outside of the chart" it will make no difference. Merely extend the line C or E, whichever it may happen to be, and go ahead with the problem.

A little study given to the chart, coupled with a few examples of your own making, will soon show why the percentage of CO should be as low as possible and why the CO_2 should be high.

If it is desired to compute the percentage of fuel loss without using the chart it may be done in this way: Divide the percentage of carbon in the coal by the percentage of $CO_2 + CO$; multiply by the percentage of CO; divide by the heat value of the coal per pound; and multiply by 10,150. The answer will be the same as given by the chart. The chart, of course, is much quicker.

In certain districts where feed water for boilers contains sodium hydroxide many boiler troubles have appeared which have given no little concern to boiler users and makers. Such water is found in the central eastern part of Illinois, in the Fox River valley in the northern part of the same state, and in portions of other states.

The Engineering Experiment Station of the University of Illinois has just completed an investigation of this source of boiler distress, and the results are published in Bulletin 94 by S. W. Parr. It was noted that boilers using feed water containing sodium hydroxide often developed fine cracks radiating from rivet holes or extending from hole to hole. The experiments showed that the effect upon the metal is to cause brittleness which makes it less capable of withstanding steam pressure and temperature changes. Among the remedies suggested is the addition of a salt having properties which cause it to react with the alkali and yield a harmless product.

Copies of Bulletin No. 94 may be obtained gratis by addressing C. R. Richards, Director, Urbana, Illinois.

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LETTERS DIRECT FROM THE PLANT

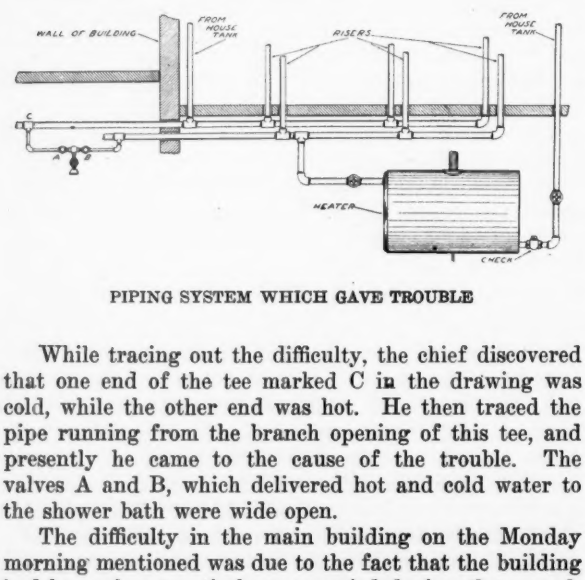
Cash Paid For Ideas Accepted. Sketches Desirable.
We Make The Drawings

A Disordered Water System

ONE MONDAY morning word came from the tenants of an office building in our town that hot water was coming from the cold-water faucets. In response, the chief engineer detailed a man to go through the building and open the faucets as he went along. In a little while the hot water ran out and cool water again appeared.

This happened before the check valve shown in the drawing had been inserted in the line. The chief concluded that the want of such a valve might have had something to do with the trouble, so he lost no time connecting it up. There were no further complaints from the tenants.

Toward the close of the week the porter of the establishment next door, which was supplied with water through branch lines from the system in the main building, came in and reported that his folks had no cold water since the previous Saturday.



PIPING SYSTEM WHICH GAVE TROUBLE

While tracing out the difficulty, the chief discovered that one end of the tee marked C in the drawing was cold, while the other end was hot. He then traced the pipe running from the branch opening of this tee, and presently he came to the cause of the trouble. The valves A and B, which delivered hot and cold water to the shower bath were wide open.

The difficulty in the main building on the Monday morning mentioned was due to the fact that the building had been almost entirely unoccupied during the preceding 36 hr., and the consumption of water from the house tank having been correspondingly low, the hot water passing through valve B had a chance to temper the water standing virtually stagnant in the system. The constant withdrawal of water through the taps during the subsequent days had prevented this condition from again maturing, and so the thermic effect of the open hot-water valve was localized, having been confined to the piping in the dependent establishment only.

Check valves to supplement the stop valves, A and B, would have prevented the trouble. A. J. DIXON.

Induction Motor Characteristics

THE CURRENT used by a 30-hp. squirrel-cage induction motor driving an ammonia compressor had been increasing gradually for several months. With an original consumption of 17 kw. per hr., it had risen to 23 kw. per hr. and ran so warm that it was feared the windings would be burned out.

As it was known that the compressor load had not increased, the trouble was laid to the motor, a conclusion justified by an examination of the stator windings which were found to be saturated with oil; the insulation was badly charred in several places.

Another motor of the same rating, but of a slightly different type was obtained; but when an attempt was made to start the machine, it was necessary for the operator to start the flywheel by stepping on the spokes before the motor would take the load, and even with this assistance it took considerable time to pick up speed. As the same compensator was used as with the first motor, which had always started promptly, the operator was unable to understand the difference, and was about to condemn the new motor, when his attention was called to the fact that the current consumption had dropped to 14 kw. per hr. This was surely unusual, as the best the first motor had ever done was 17 kw. per hr.

Realizing that there must be some explanation for the difference in conduct of the two machines, the operator made some inquiries with the result that he learned a few points concerning induction motors, some of which were as follows: The resistance offered to the flow of the induced current in the rotor of an induction motor determines largely the characteristics of the machine. If the rotor bars, or conductors, offer considerable resistance to the flow of current, the starting and running torque of the motor will be greater than would be the case if the rotor circuit was of low resistance; but the current consumption (for the same amount of mechanical output) of the machine having the greatest resistance and torque, will also exceed that of the motor whose rotor offers the least resistance. The cause of this is due to the fact that the impedance of the rotor circuit is made up of the induction and resistance of the circuit. Increasing the resistance causes the consequent rotor poles to occupy a position relative to the stator fields, which enables the flux or lines of force to act at best advantage. This, of course, increases the torque and consequently the current consumption, but should the resistance of the rotor circuit be reduced, the lag of the rotor current will be increased and the consequent poles of the rotor will (due to the characteristics of an induced current) coincide more nearly with the revolving fields of the stator, thus reducing the effectiveness of the flux which in turn reduces the torque, but with the ad-

vantage of also decreasing the stator current or power consumption of the motor. Therefore, it is seen that the induction motor characteristics are, in reality, a compromise between the resistance and induction (i.e., reactance) of the rotor circuit.

The operator decided that the first motor had considerably more resistance in its rotor circuit than the second, but by placing a larger bypass on the compressor so as to reduce the starting load, the second motor would in a year's time (operating 20 hr. a day with current at 3 cents per kw.-hr.) save $657. A. C. McHugh.

Stuffing Box Trouble

Some engineers follow the rule of putting in 1 or 2 rings of packing on top of the old packing already in the stuffing box as often as the gland is screwed up far enough to permit it. This is good practice with well fitting stuffing boxes and good smooth rods, as it adds to the economical operation of the plant; but with old or scored rods it is bad practice, as the packing already in the stuffing box is uneven and generally worn on one side and causes the new rings to wear very quickly on the same side and leak and more new packing has to be used. This is also caused by the hole on the side of the rod at the bottom of the stuffing box being larger than on the other side, caused sometimes by the metal breaking out, allowing the packing to be pushed through into the cylinder, in which case the remedy is to put in a metal ring at the bottom of the stuffing box to stop up the hole and prevent the packing from being pushed through.

I have seen some cases, however, where the stuffing box was so short that to put in a metal ring would leave no room for packing, as the box would not hold more than two rings after the job had been done; so the old stuffing box was cut off the cylinder head or frame, as the case was, and the hole reamed out and tapped. A new stuffing box was made in the shape of a nipple, screwed into the head tight up against a shoulder on the nipple, to prevent its working loose, and in one instance where the stuffing box was large, the shoulder was made a flange and bolted onto the head instead of being screwed into it. Where the rod is badly worn, leaving considerable space between the rod and the hole through the gland, the packing would, when worn, be pulled out through this space and cause sufficient annoyance, with a condensing engine, to cause a shut-down, as this leakage on the backward stroke would admit enough air to cause a considerable lowering of the vacuum, if not the entire loss.

I had a case where the gland vibrated so badly as to hammer the check nuts loose on two 7/8-in. bolts and drive them back on the bolts so quickly that I had to call the assistance of an oiler to hold one with a wrench while I tightened the other.

We were using two of these 350-hp. Armington & Sims engines, running 210 r.p.m. The gland fitted the stuffing box well in the other engine and we were not troubled by the nuts working loose unless the packing became loose in the stuffing box, but the rod was scored somewhat and badly worn. It was not desired to make any repairs on these engines, as new units were soon to be installed in their places. But to keep them running, a special sample lot of packing was obtained and tried on the second engine, which usually ran 16 hr. a day and had to be repacked every third day, requiring 4 lb. of the old packing, 6 rings; 5 lb. of the new packing, 5 rings, at much higher price, the price being the only reason this packing was not used. But the manufacturer put in this sample with the guarantee that if it did not outwear the other packing about 3 times he would not present any bill for it. This sample lasted 5 weeks, the price being slightly more than double the other packing, but in the end was so extremely cheap that the entire plant was supplied with it.

We were given by this manufacturer special caution not to fill the stuffing box up too full, as this was a round packing pressed into a square shape with extremely good expanding qualities when heated. It should not be tightened up with a wrench until after it has been run a few days. It was expected to blow some on the start. Four rings were put in the stuffing box and screwed up as tightly as possible with the bare hand. It put steam over the crank on the start and a heated argument started between the engineer and the chief. The gland was tightened up with a wrench by orders, then it leaked some for about half an hour, when it gradually stopped. With copious oiling for a time, good results were obtained. R. A. Cultra.

Engine Troubles

The dashpot rods on a Corliss engine were not in line with the valve rod crank bearing, as shown in Fig. 1A. The bearings would bind, causing the dashpots to work improperly. The dashpots were not placed in the right position by the erector of the engine. The trouble was remedied by placing copper washers at the joints as shown in Fig. 1, to bring the 2 dashpot bearings in line.

On this same engine it was found that the exhaust valve rod bearings did not come in line with the crankpins on the valve rods and bearing pin on wristplate, causing them to bind. The trouble was remedied by

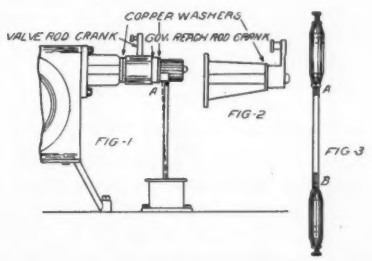


FIG. 1. DASHPOT OUT OF ALINEMENT
FIG. 2. METHOD OF LINING UP VALVE ROD BEARINGS
FIG. 3. DASHPOT ROD POORLY ASSEMBLED

placing a copper washer between the bearing face of bonnet and rod valve crank, as shown in Fig. 2.

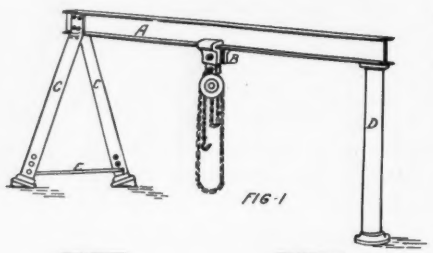
At one time, there appeared a pound at the crosshead of this engine, and I thought at first there was lost motion at the pin or crosshead shoes; but in looking for the cause, I found that the eccentric was running dry, which caused the pound, but which appeared as if it was at the crosshead. The eccentric is lubricated by means of a grease cup which stopped feeding, unnoticed by the engineer. After the eccentric received lubrica-

tion the pound disappeared. Many times we find that one end of the dashpot rod is turned in one head much more than the other, as shown in Fig. 3 at A and B. This looks bad, besides it weakens the joint where the rod end is perhaps held by a few threads. It is a matter of carelessness and can easily be remedied.

H. A. JAHNKE.

Handy Substitute for Crane

FOLLOWING is a description of a sectional A-frame or tripod which I designed to use on machinery where there is no overhead crane or where the base of a patent portable crane cannot be slipped under the machine. It is also useful in places where a hitch for a chain block would require rigging or high climbing. Another advantage is that the clamp or trolley, B, can be slid along the beam to move pieces to one side when they are lifted clear. The chief advantage of this frame is the one vertical leg on one end. Column D can be placed in spaces where an ordinary A-frame would not go, and, if necessary, a short length may be kept on hand to rest on parts that are higher than the floor. The difference in heights can be made up by blocking under either end. By drilling a series of holes for it in the beam, it can be put under various parts of the beam.



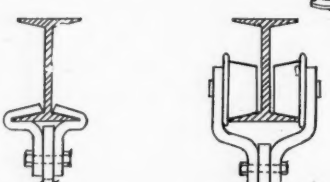


FIG. 1. A-FRAME CRANE COMPLETE
FIG. 2. CLAMP TO HOLD TACKLE
FIG. 3. TROLLEY TO TAKE PLACE OF CLAMP

The clamp, B, can be replaced by a trolley, which will be more convenient. Never tie a chain over the top of the beam to hitch onto, except for light loads, as this puts the load in a top-heavy position.

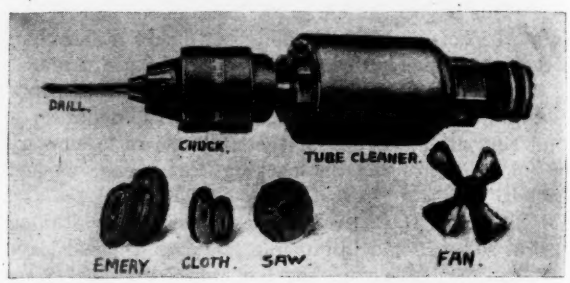
A frame of the following size and dimensions is good for one ton steady load, and by making it larger and the parts heavier, it will stand a heavier load. The beam is a standard 6-in. I-beam, 17¼ lb. per ft., and is 9 ft. long. Column D is a piece of 4-in. pipe 8 ft. long, with ordinary flanges on each end and one end bolted to the beam with 4 ⅝-in. bolts. The 2 legs, C, are pieces of 3-in. pipe flattened down and bent at the proper angle by forging. The lower flange of the I-beam should be cut away to allow the 2 legs to form an acute angle, as when the angle is too great they are liable to spread. To prevent this, a small tie rod, E, is bolted between them. The 2 legs are fastened to the beam by 4 ¾-in. bolts running through both pipes. The lower ends should have a pair of pipe flanges on them with tapered hardwood blocks bolted to the flange faces. The blocks should be the correct angle to make the legs bear evenly on the floor.

Figure 2 shows a plain clamp which can be slid along the beam if it doesn't fit too tight. Figure 3 is a section of a trolley that can be rolled along easily into any position. A 1-ton chain block completes the outfit.

LEO F. GRANDMONTAGNE.

Novel Uses for a Tube Cleaner

IN THIS age of appliances all engineers try to make use of as few appliances as possible. The illustrations herewith show a water tube cleaner, air or steam driven, with a drill chuck attached. The other appliances shown should have an adapter for assembling them on the spindle of the cleaner. One is an emery wheel, another is a buffing wheel, which saves metal polish and lots of hand rubbing. Another is a saw which can be attached to the



BOILER TUBE CLEANER AND ATTACHMENTS

tube cleaner and can be used portably, but is safer with the tube cleaner clamped to a bench, or some other solid support. Last, but not least, is an old automobile fan, just the thing when working in warm places such as fireboxes, combustion chambers and boiler-drums. These attachments may be had at very little expense and will pay for themselves in a short time. W. A. JONES.

Trouble With Intercooler

PERHAPS THE TROUBLE experienced by Mr. MacCamy, related in the May 15 issue, in the operation of his compressor was due to a leaky coil in the intercooler, allowing the cooling water to mix with the air in the air space of the cooler and be carried on to the high-pressure air cylinder. If the pressure of the cooling water in the coil of the intercooler was greater than the air pressure on the outside of the coil, it would, of course, be possible for water to leak into the air space of the cooler and eventually get to the high-pressure air cylinder.

C. T. BAKER.

Two Waste Saving Hints

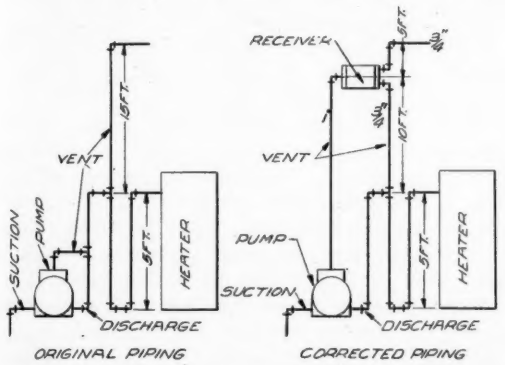
MONKEY WRENCHES or Stilson wrenches, when broken, may often be taken apart and the good pieces assembled into other wrenches.

Broken pieces of asbestos may be pulverized, mixed with water and reused for lagging pump cylinders or fittings.—Factory.

Eliminating Vent Discharge

A HEATING PLANT with vacuum return, which necessarily had a vent in the return pump discharge, open to the atmosphere, always caused trouble by allowing water to escape from the vent.

Although the pressure in the heater never exceeded 3-lb. gage, and the vent was 20 ft. high, there was an undesirable discharge, which was remedied by changing the vent as shown by the accompanying illustration. The receiver was made of a 4-in. nipple about 8 in. long,



PIPING BEFORE AND AFTER INSTALLING RECEIVER

with a reducer on one end to take a 1-in. pipe, and a cap on the opposite end drilled and tapped for 2 ¾-in. pipes.

The result was very satisfactory.

J. M. Row.

Removing Grease from Surface Condenser Tubes

WE HAVE FOUND that the tubes of our surface condensers must be cleaned once every 6 mo., both inside and out, in order to maintain a high vacuum. The outside surfaces of the tubes become quite badly fouled with grease and sediment. The sediment consists of scale particles and grit, abrasive dust from the turbine blades, the walls of cylinders, etc. Our feed water is all filtered before being fed to the boilers, yet this foreign matter gets through to the engines. It is not really possible thoroughly to wash it all out.

The grease that adheres to the tubes forms a soft, spongy coating in which this sediment imbeds itself, this condition being the worst, or more serious, over the upper rows of tubes at the exhaust inlet, the baffle plates receiving a large deposit.

Our first attempt to remove this fouling was as follows: The vacuum space was filled ⅔ full of fresh water, and 30 lb. of boiler compound was introduced. The water was then boiled by means of live steam admitted into the bottom of the shell, and this allowed to boil for 20 hr., and to overflow through the upper manhole of the shell, the scum rising and flowing off with the condensate formed. This removed the grease, but caused considerable trouble with leaky tube sheets, the packing around tube ends having suffered. Considerable repacking was necessary to make them tight again.

The next method used—and the one we still use, is to fill the shell with hot water, 180 deg., and add, or mix, 50 lb. of caustic soda. This is then circulated, a suction being taken from the bottom, and pumped back through the manhole through a fire hose and nozzle, this directed as much as possible to reach all the area. This dissolves the grease, which is kept in solution. After 4 hr. circulating, it is drawn off at the bottom, and the tubes are then washed with clean water. This method does the work very well, and no trouble has yet been experienced with leaky packing.

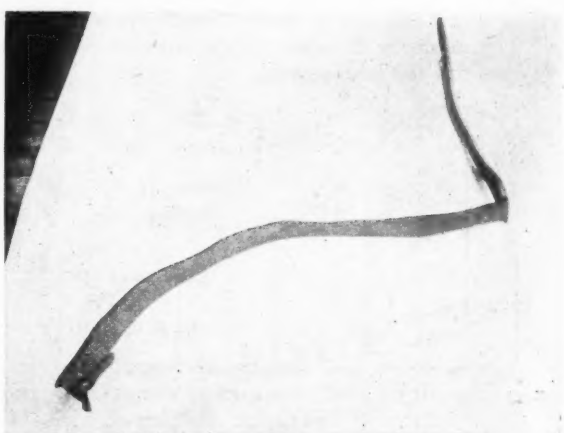
The interior surfaces of the tubes are cleaned once a year with Lagonda air-driven condenser tube cleaners. The circulating water used in this condenser, coming from a water cooling tower, is used many times, and carries considerable sediment. This is flushed out about once a month, using a hose with 30 lb. pressure.

C. H. WILLEY.

Slice Bar "Explosions"

JUST WHAT may be expected to happen to a poker or slice bar by having both ends closed, is shown in the accompanying illustration. This bar was made of 1-in. black lap-welded pipe about 8 ft. long. A piece of steel was welded to one end and flattened out like a chisel; the other end was closed by being welded.

One day, during the noon hour, the fireman was about cleaning his fires when the bar exploded, leaving it in the form shown, and with the fireman rendered unconscious and in general badly battered up.



THE RESULT OF USING A CLOSED SLICE BAR

If any engineer or fireman finds it necessary to close both ends of a poker or slice bar or any other firing tool, the body of which is made up of piping, I would advise drilling one or two ⅜-in. holes near one end.

O. L. C.

Stoker Engine Repair

I RECENTLY HELPED repair a Detroit stoker engine, and believe a description of the method employed may help some brother engineer.

The rod became disconnected at the crank and broke out a section of the trunk piston, destroying about 1/3 the diameter and depth of the body of the piston; one snap ring was also broken. Instead of ordering a new one, the chief engineer had a machinist fit a new ring to the piston just above the break. I reassembled the engine and it is now working fine. J. C. LEE.

Questions Answered and For Answer

Expert Help When In Trouble. If You Want Quick Answer Enclose a Stamp

Civil Service Examination Questions

THE FOLLOWING questions, to which answers are given here, were asked in a recent Civil Service Examination for the position of Second-Class or Assistant Engineer of Public Buildings in the Departmental Service. They were submitted to us by Raymond J. Cary of Fitchburg, Mass.

1. Why are zinc plates hung in a boiler?

Zinc is often used in boilers to prevent the corrosive action of water on the metal, the zinc forming one pole of a galvanic battery and the boiler shell the other, with the result that the zinc is eaten away and the iron is protected.

2. Sketch an average indicator diagram, and tell how to figure the indicated horsepower.

To find the horsepower of an engine is best and easiest done by means of a planimeter, by which you can get the mean effective pressure directly from the card, and then using the formula, P L A N ÷ 33,000, which will give you the horsepower.

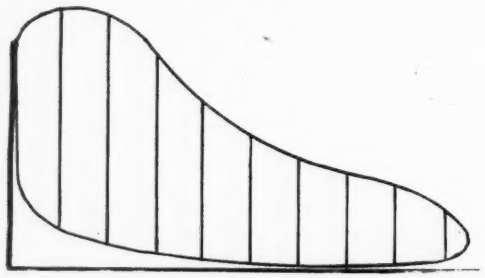


FIG. 1. FORM OF INDICATOR CARD COMMONLY MET IN PRACTICE

In this formula, P = the mean effective pressure in pounds per square inch; L = the length of the stroke in feet; A = the area of the piston in square inches; N = the number of strokes per minute.

If, however, you have no planimeter at hand, the mean effective pressure can be found by computation. This is done by dividing the diagram in the manner shown in Fig. 1.

The object here is to obtain the mean height of the 10 rectangular sections into which the diagram may be assumed to be divided. Each of the ordinates may be measured by the scale corresponding to the spring used, and the pressures so obtained added together; the result, divided by 10, will give approximately the mean effective pressure per square inch throughout the stroke, after which you can use the above formula to get the horsepower.

3. Sketch a sight feed lubricator and tell how it works. Sketch same on horizontal and vertical pipe.

A. A hydrostatic lubricator of the sight feed type, as shown in sketch, operates as follows: The lubricator is filled with oil by removing cap K, the height of oil appearing in glass L. If water is present, the oil floats on top, as indicated; after the cap is screwed in place the valves in the condenser pipe are opened, subjecting the oil in the vessel to steam-pipe pressure. Steam is condensed in pipe C, filling tube B and part of C, thus adding to the steam pressure the pressure due to the weight of the water column. Valve F, which communicates with the top of the vessel by means of tube A, is opened wide as is also the regulating valve, I. The pressure at B being greater than that at A by the amount equivalent to the height of the water column, forces the oil through A and the "sight feed," S, to the steam pipe. The rate of flow is controlled by regulating valve I. As the oil flows from the vessel, its space is occupied by condensed steam.

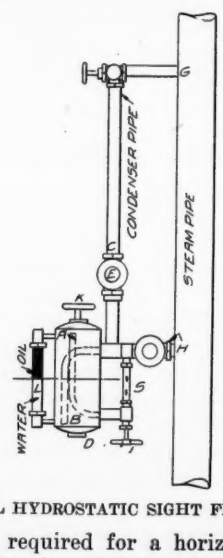


FIG. 2. TYPICAL HYDROSTATIC SIGHT FEED LUBRICATOR

No change is required for a horizontal connection, except for the extension of the condenser pipe which is bent in the form of a loop to bring the condenser pipe inlet and oil discharge level.

4. What is a piston valve? A D valve?

A. A piston valve consists of one or more pistons, mounted on a rod or spindle, and usually designed to correspond with annular spaces in valve chests. In construction this type of valve may be either single or multiported, may or may not have lap or lead, and is ordinarily considered to be balanced.

A flat or slide "D" valve is made in one piece, having one or more chambers on the inner face. Its design is such that it controls the admission, cutoff, compression and release of the steam, and it is not balanced.

5. What effect has air in a hot water or steam radiator? How is it removed?

A. The presence of air in a radiator interferes with the complete circulation of the steam or hot water through the radiator, and lowers the radiating efficiency of the radiator. Air is discharged from the radiators through automatic valves on steam radiators and manually controlled valves on hot water radiators.

6. Describe and sketch a plumber's trap; show water seal and vent.

A. Where the ordinance does not require a catch basin, the piping arrangement shown in Fig. 3 is employed, the closet and wash basin being provided with usual plumber's trap or water seal, while the bath tub has a simple drum trap. Vent pipes provide an escape for foul gases and the connection from each trap is made at a point at least 3 ft. above the floor to prevent the fixture from wasting through the vent should the waste or soil pipes become stopped.

7. What is the difference between a jet and a surface condenser? Tell where each could be used to best advantage.

A. A jet condenser is one in which the steam exhausted from engines or turbines is brought into intimate contact with a supply of water, which, cooling the water, condenses this steam and creates a vacuum. A surface condenser is one consisting of a large cast-iron chamber containing many small tubes, usually made of brass. Through these tubes, cold water is circulated, while around these tubes, the steam from the engines, turbines or pumps, as the case may be, is carried so that, as the steam comes in contact with these comparatively cold tubes, it is condensed, forming water and creating a vacuum.

The jet condenser may be employed if the water is pure, while the surface condenser is advantageously used where the water is salty or impure.

8. Describe the ammonia compression system of refrigeration, and trace ammonia through one complete cycle.

A. An ammonia compression system of refrigeration is operated by means of a gas pump or compressor. Starting the cycle is the compression of the gas to about 150 lb. Next a withdrawal of the heat caused by compression by means of cold water in contact with pipes containing the ammonia gas, and then the expansion of the liquid and absorption by it of the heat of the brine water or air to be cooled. It is then returned to the compressor, the process being an alternate compression and expansion of the refrigerant.

9. Which is best on main line circuit of direct-current, fuses or circuit breaker?

A. A circuit breaker is best installed on a direct-current main line, because their operation is much more certain and rapid than that of fuses.

10. Where is the starting box of a direct-current motor connected?

A. The starting box of a direct-current shunt-wound motor is ordinarily connected in series with the armature; in the case of a series wound machine it is connected in series with both armature and field windings.

11. Explain how you would fit new brushes on a direct-current generator.

A. Box-type brush holders should be adjusted so that they clear the commutator about $\frac{1}{8}$ in. They may all be uniformly set to this spacing if a strip of wood is inserted between the holder and the commutator and the box set down to this gage. The copper plating should always be kept scraped off for a distance of about $\frac{1}{4}$ in. from the end to prevent a localized contact with the commutator due to the low resistance of the copper.

Reversing motors are best operated with the brushes set radially to the commutator unless operation in one direction predominates. On other dynamos the brushes should form an angle of about 15 deg. with the radial line of the commutator, the outer end of the brush being in advance of the face. The brushes should be in front of the stud in order that they may be forced onto the commutator rather than lifted from it by any irregularities.

12. What is an equalizer and where is it used?

A. An equalizer connection is a third busbar connection extending from the + brush of one dynamo to the + brush of another when 2 or more compound machines are being operated in parallel. The equalizer

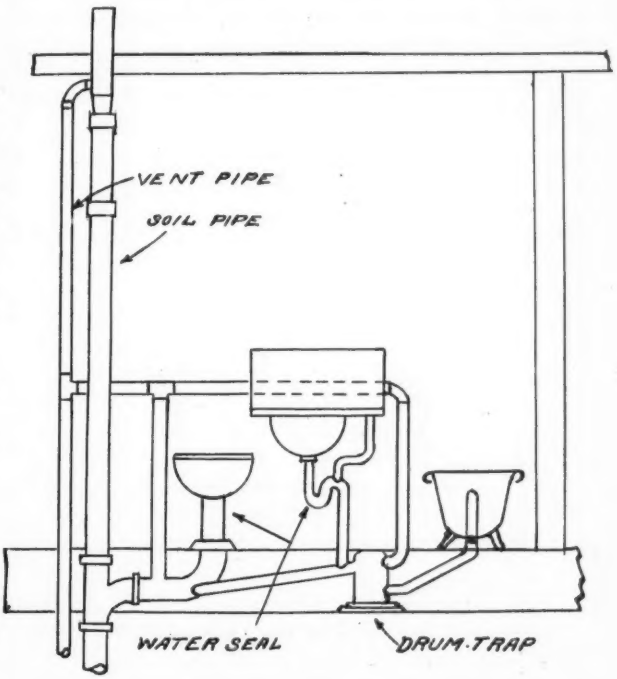


FIG. 3. APPLICATION OF TRAPS USED IN CONNECTION WITH PLUMBING EQUIPMENT

is always a conductor of low resistance, its purpose being to put the series fields of the different machines in parallel so that no matter what current flows through a given armature, the division of current through the series field is always the same.

13. How are the armature windings of a d.c. generator held to the commutator?

A. For drum windings, the armature coils are set in a toothed armature core which is built up of sheet-steel discs in the outer periphery of which teeth have been cut and slots formed, 2 typical slots being shown in Fig. 4. After the coils are placed a strip of fibre or wood is inserted at the top of the slot to hold them securely in the core.

14. If the circuit breaker blew out on the main line of a d.c. circuit, what procedure would you go through to get it in service again?

A. If the circuit breaker was thrown out by a short circuit, it should not be closed until the short circuit is removed; and for the protection of the motors on the circuit, it should not be closed until controllers or starting-box levers have been moved to the starting position.

When these precautions have been observed, the circuit may again be closed.

15. If the circuit breaker on a shunt-wound motor suddenly opened, what effect would it have on the motor?

A. If the circuit breaker on the supply line to a motor opened it would merely result in the stopping of the motor.

16. When is "undercutting" resorted to on a commutator, and why?

A. Undercutting or slotting of the commutator is a cutting down of the mica insulation between the commutator bars to eliminate the tendency for the commutator to collect smudge due to high mica. The mica is ordinarily undercut 1/16 to 1/8 in., depending upon the size of the machine.

17. In an electric elevator with full magnetic control, does the current which passes through the armature of motor pass through operator's control switch?

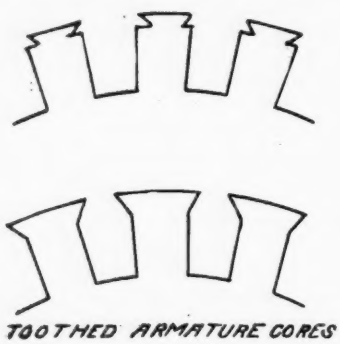


FIG. 4. TYPICAL FORMS OF ARMATURE CORE SLOTS

A. In direct-current, full magnetic control elevators, the armature current does not pass through the operator's controller, but passes through a current relay.

18. What stops an elevator if the cable breaks?

A. The principal safety of electric elevators is an electro-mechanical wedge clamp safety (described in detail on page 456 of the May 15, 1916, issue) consisting of a magnet controlled helical spring which forces wedges between the rollers of the safety jaws sliding over the guide rails. When the car is in service, the spring is held in compression by means of the electro-magnet; but the instant the current to the magnet is interrupted, either by the centrifugal governor, safety switch in car, or limit switches in the hatchway, the spring is released and the retarding safety jaws grip the guide rails.

Safety stops on hydraulic elevators ordinarily consist of automatic devices in the form of wedges, pawls, etc., which are thrown into action by excessive speed of the car or by the breaking of the cable.

19. Explain in detail the effect on boiler plates of lime, magnesia and vegetable matter in feed water.

A. The presence of the bicarbonates of lime and magnesia or the sulphate of lime in boiler feed water produces scale on the boiler shell. These compounds are ordinarily precipitated when the water is heated to 200 or 300 deg. F., although soluble in cold water.

Vegetable matter in feed water may cause corrosion or scale formation, the corrosion being produced by the fatty acids present in the vegetable matter, while scale may be produced by the accumulation of suspended matter. W. P.

Correcting Engine Trouble

IF YOU take up on crosshead pin, and have some lost motion in guides, would the taking up of pin tend to make crosshead pound in the guides—provided the crosshead had run quiet previous to taking up?

2. Could you suggest some method of stopping a dashpot from striking the bottom when you cannot get it to cushion with regulating screw?

3. What would cause the steam valve on a Brown engine to ride on the latch block and not unhook?

4. Why isn't there a take-up on some engines on the outboard bearing? L. B.

ANSWERS

CROSSHEAD PINS naturally wear flat on the sides that are exposed to the thrust of the rod, and although many devices have been used to prevent this, yet wear will occur, although in many instances it is very slight—possibly not over a thousandth of an inch. And if the lubricant is dirty, or the engine exposed to dirt or dust that can find its way into the bearings, this wear will be more noticeable. So, while the engine might run along without any noticeable looseness at the pin, yet if it be taken up ever so slightly, the tendency will be to grip the pin at each extreme of travel, which occurs at that point of the stroke where the crosshead pin, crankpin and shaft form a right-angled triangle; and if the pin be gripped, even slightly, there will be a tendency to disturb the alinement of the crosshead if the shoes are at all loose and cause pounding.

The best way out of such a trouble is to put the crosshead pin in a lathe and take a fine cut over it; or better still, grind it, and when true, scrape the pin brasses to an absolute fit. Then see that the pin is relieved top and bottom, so that the brasses over-run this shoulder at each extreme of travel.

2. When the dashpot strikes the bottom in spite of the best efforts to adjust the regulating valve, the probabilities are that either the cushioning leather is worn out and missing, or that the screws which hold it protrude enough to strike before the leather does. Look into this matter first, and if you find nothing amiss, then you can be sure that your valve gear is so finely adjusted that the usual amount of friction calculated by the builders is missing and is not enough to counteract the vacuum in the pot, which causes prompt closing.

The writer once had just such a difficulty as you have and overcame it in the following manner: The cushion valve was located at a given distance from the bottom of the pot, according to the standard as laid down by the designer. This valve was removed and a new hole drilled and tapped in the pot about half an inch higher, and the valve placed in this, and the old hole plugged. A little experimenting soon gave us the desired result and we had no further trouble.

3. The steam valve on any make of releasing-gear engine will "carry" if the load is heavy for the pres-

sure carried, or the pressure low for the load. If the cutoff rods are not properly adjusted, you will sometimes notice that when the limit of the engine has been reached so far as present speed and pressure are concerned, one or the other of the valves will "carry," and if you apply the indicator you will find that the end at which this occurs, is carrying the greater load. It only remains for you to adjust the knockoff rods (and also make other necessary adjustments) so that the load will be equally distributed between the two ends of the cylinder.

4. This is mainly a question of dollars and cents. Competition is sometimes so keen between manufacturers to furnish an engine of a given capacity for a purchaser, that every effort is made to reduce the cost of manufacture by eliminating many of the little refinements that go to make a really good engine.

Where an engine has wedges front and rear in the main bearing and a screwed piston rod, the shaft can be kept square with the center line of the engine by means of the wedges, and in such a case it is really immaterial whether the outboard bearing is adjustable or not. But if there is but one wedge in the main bearing (it is usually in front of the shaft), it is easy to see that while the wedge takes up the wear in the main bearing, it gradually throws the shaft out of square.

The average purchaser does not note this discrepancy when signing the contract, and, in fact, if the engine is properly erected, the discrepancy will not be apparent for several years. Again, in some of the smaller sized engines no means are provided in either main or outboard bearings for adjustment more than purely local, as frequently the lower bearing is integral with the frame and incapable of being moved from its original position, so that when wear does come, as it will from the strain of the drive belt, it is impossible to compensate for it.

On direct-connected units, while the stator can be moved a small amount to preserve the equality of the air gap, yet there will eventually come a time when the limit has been reached, and if no provision has been made for adjustment in the engine bearings, electrical difficulties will come up that are annoying, and for which there is no immediate remedy, owing to an engine of improper design to meet existing conditions.

The writer once encountered a 2-cylinder gas engine of about 200-kw. capacity, where the outboard bearing consisted of the time-honored pillowlock without adjustment. Naturally, owing to the high pressure of the exploding charge, there was a constant strain on the outboard bearing so that in about 6 mo. it had considerable lost motion sidewise, which interfered more or less with the generator. The only remedy was to re-babbit the outboard bearing every so often, until the limit of patience had been reached, when the owner purchased a new adjustable bearing which solved the difficulty.

G. H. WALLACE.

Universal Motors

WILL YOU kindly tell me if electric motors of any size are made which may be operated on both alternating and direct-current circuits? If so, by whom are they built?

I desire to obtain a motor of this kind having a rating of about 2 hp. A. J. B.

A. We presume you are referring to so-called "universal" motors. These are motors which operate either upon alternating current or direct-current, either without any change whatever in the adjustment of the motor or with the addition of external resistance, or with one or both of these features. Such motors are necessarily series wound and possess a speed torque characteristic in general similar to a series wound direct-current motor and as a consequence their application is limited to disc types of fans, blowers, electric tools, etc., where a positive load is carried.

Motors of this type are only built in comparatively small sizes and we doubt whether you could get one capable of developing as much as 2 hp. We would, however, suggest that you take this matter up either with the General Electric Co., of Schenectady, N. Y., or the Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., who could advise you more definitely. O. H. H.

Vacuum Pump Calculations

WILL YOU kindly give me the formula for determining the mean effective pressure of an 18 by 12-in. vacuum pump operating at a speed of 200 r.p.m., and with vacuums ranging from 1 to 29 in. at the intake and discharging at atmospheric pressure? Also, the formula for finding the theoretical amount of air discharged or displaced by this pump at the different degrees of vacuum. C. S. G.

A. The theoretical mean effective pressure of a vacuum pump may be found as follows: The formula for work is

$$W = p_1 v_1 \times \log_e r,$$

in which

W = the work in foot pounds per stroke;
p_1 = the initial pressure per square foot in pounds absolute;
v_1 = the displacement volume of the cylinder in cu. ft.
r = ratio of expansion = the high pressure divided by the low pressure, both in pounds absolute.
$\log_e$ = hyperbolic logarithm.

Having found the value of W, divide this by the length of the stroke in feet, and divide again by the area of the piston in square inches, and the result will be the mean effective pressure.

The absolute pressure for the various degrees of vacuum in inches of mercury may be had from the steam tables.

The formula for the volume, or the theoretical amount of air discharged is $p_1 v_1 = p_2 v_2$, in which

p_1 and v_1 are as above, and in this case
p_2 and v_2 are the atmospheric pressure in pounds absolute per square foot, and the volume in cubic feet at atmospheric pressure.

From this we get that, $v_2 = \frac{p_1 v_1}{p_2}$

v_2 is then the volume of free air discharged per stroke of your pump. Both of these formulas are theoretical, no account being taken of the clearance in the end of the cylinders, the slip of valves, or the temperature of the air. R. E. T.

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A Duty for Everybody

In the present crisis, every citizen must serve. Our Nation is facing a test involving the defense of our honor, our rights and the liberty of humanity throughout the world. To fail is to confess ourselves unworthy of the heritage that has come down to us from the fathers of this Republic, and we must not fail.

To ensure victory, full popular support of this Government is as necessary as armies, navy and supplies. Supplies and equipment cannot be bought by the Government unless they are on the market, and the funds are available. Hence, popular support means that everybody sees to it that food, clothing, munitions, materials are produced abundantly, and that funds are supplied for purchasing them.

Making each day's work count fully for production is as much a patriotic duty and service as fighting with a gun or flying an airplane. For every fighting man at the front, 12 men are needed at home; patriots on the farm and in the shop are as necessary as those in the trenches.

And to supply the funds means thrift, economy, and loaning to the Government the money thus saved. That is not a gift. It is good business; but it is also a real service. No other small investment, or large one either for that matter, has quite the advantages that the Liberty Loan Bond has. Savings invested in a Liberty Loan Bond are just as safe as it is possible to make them and will constantly draw interest. While interest is only 3½ per cent, the bonds being nontaxable makes the investment the equivalent of a 5 or 6 per cent interest-drawing investment in ordinary securities.

The patriotic nature of an investment in the Liberty Loan Bonds of 1917 is something that all Americans will consider. The fact that in purchasing such a bond the investor is lending his money to his Government—to his country—to prosecute a great war, gives the investment a dignity that the ordinary investment does not possess. The uses to which the money is to be put, the noble purposes to which it is to be devoted, all are things which appeal more or less to the American heart.

Investment in the Liberty Loan will also aid to make good business. Practically all of the proceeds of the Liberty Loan, whether advanced to foreign governments or expended directly by departments of the United States, will be spent in this country in payment of indebtedness heretofore or hereafter incurred.

The meaning and importance of that to the subscribers to the Liberty Loan is clear. The United States is not asking for subscriptions to a $5,000,000,000 bond issue to be sent out of the country. Every dollar is to remain here and while we are aiding our allies by loaning funds to them at a lower interest than they could get otherwise, we are aiding ourselves by providing new demands upon all of our industries. That means increased demands for labor, more requirements in raw material and a greater market for food products.

There is another point to which wise and thoughtful people will give due consideration, and that is an investment in Liberty Loan Bonds is an investment in the defense and preservation of all their other property and all they hold dear—the preservation of their liberties. We would be in danger, if all our citizens refused to lend their money to the Government, of losing all that

we have—our property, our liberties, and our national honor. It has come to this, that we must fight for these things, and to wage war in this day and time requires not only men and arms but great sums of money.

Subscribers to Liberty Loan Bonds are charter members of a society to maintain American honor and to maintain democracy here and in other parts of the world. Honor and interest, patriotism and business judgment all argue the wisdom of an investment in Liberty Loan Bonds.

Banks, National and State, post offices, and express companies have been designated as agents of the Government to receive applications for these bonds. It is almost as easy to purchase one of these bonds as it is to get a post-office money order.

It is not necessary to pay cash in full for a bond. One can pay down 2 per cent of the purchase price on application—that is, $1 for a $50 bond, $2 for a $100 bond, etc.—18 per cent on July 25, 1917; 20 per cent July 30, 1917; 30 per cent Aug. 15, 1917; and the balance, 30 per cent, Aug. 30, 1917.

Most banks and many business firms have also arranged to sell the bonds of the Liberty Loan on a weekly instalment basis. For a $50 bond, the first payment will be about $2 and the weekly payment about $1.75, the bond being entirely paid for by Dec. 15, 1917.

Patriotism, good judgment, thrift, security of investment, all point to the purchase of a Liberty Bond as an immediate duty.

Encouraging Initiative Among Subordinates

Nothing more quickly marks an executive engineer of the highest grade than the willingness of such a man to encourage subordinates to develop powers of initiative. And on the other hand, nothing sets a plant chief among the narrow-minded class of leaders so soon as a hostile attitude toward originality among those under him. It is strange that many men still fail to see that it is highly creditable to their own administrations to develop ability latent in their organizations; that no plant owner or executive worth working for will think less of an engineer executive because one of his subordinates does exceptional or in some cases brilliant work, provided the chief himself maintains an open mind at all times toward improvements.

No greater mistake could be made by an executive engineer than to berate a subordinate for showing initiative that results badly. The next time it may happen otherwise. It is worth going to some expense to try out suggestions that look promising, even if they do not in the end prove satisfactory. Of course, few plants can afford to modify their general design to test out uncertain ideas; but where changes in methods can be put into effect at moderate cost or where certain rearrangements of minor equipment can be tried at least temporarily, much good may result from giving the man with initiative a chance to show the value of his contentions. If the chief "calls down" a subordinate for showing initiative, the chances are ten to one that he will not have another opportunity, and unless the under man is exceptionally full of "pep," the welfare of the plant is apt to be regarded with indifference for some time to come as far as the rebuked employe is concerned.

Many an engineer could learn something from the way in which a newly appointed chief executive took command of a property not long since, after having served his time in the lower ranks. Calling his staff into his office down to the most humble member, he told them in the straightest possible fashion that results were what he was after; that every man would be allowed to do his work in his own way provided those results were attained; that he remembered hearing many of the men before him state in the past what this or that man would do if he were head of the company; and that each man now was to be given the chance to make good. The new chief promised either to show his subordinate in each case that his ideas were impracticable or to adopt them, and invited the utmost freedom of suggestion from everyone in the conduct of affairs. In this organization it is not far from the truth to say that if the "Big Chief" requested it, just about every man on the payroll from the watchman to the chief engineer of power installations would jump into the condensing water pond in the full confidence that he would return to dry land uninjured. How much better such a policy is when consistently maintained than the old, out-of-date, dog-in-the-manger attitude which takes full credit for all suggestions advanced, which conceals the name of the subordinate whose fruitful ideas are adopted, and which condemns, sometimes with cutting sarcasm, opinions on behalf of plant betterment which may or may not be superior to the views of the head of the station!

What can the young engineer with initiative do in a case where his immediate superior refuses to encourage initiative, perhaps denying him even a fair hearing upon the merits of the proposition? First, he should make himself as sure as possible that his proposals are worth while to the extent of a thorough investigation; and second, after reasonable efforts and patience have been exhausted, he may very properly decide either to seek another post or to appeal to the superior of his chief for an opportunity to try out his plan. This is a painful course in many cases, and is "not to be entered into lightly, but soberly, discreetly and advisedly," in the sound belief that by such a route lies the only opportunity for the progressive man to advance in his profession. Certainly, if any chief engineer becomes so encrusted with self-sufficiency as to deny his subordinates earnest and welcome consideration of all their suggestions for improvement, no matter how chimerical some of these may appear, the time for his resignation cannot be far distant. Fortunately, for the honor of the operating engineer's profession and for its reputation as a progressive branch of the world's industrial army, the great majority of plant chiefs are thoroughly alive to the display of initiative on the part of their subordinates and over and over again are doing all they can to encourage this priceless quality.

He has achieved success who has lived well, laughed often and loved much; who has gained the respect of intelligent men and the love of little children; who has filled his niche and accomplished his task; who has left the world better than he found it, whether by an improved poppy, a perfect poem or a rescued soul; who has never lacked appreciation of earth's beauty nor failed to express it; who has always looked for the best in others and has given the best he had; whose life was an inspiration; whose memory, a benediction.—Stanley.

Power Apparatus in Shop and Market

New Ideas In Making, Buying and Selling

Combined Steam Turbine and Centrifugal Boiler Feed Pump

RECENT development in the direction of compactness and simplicity of turbine-driven centrifugal pumps is shown by the accompanying illustrations, showing a 3000-hp., 2-stage centrifugal boiler feeder combined in one casing and on one shaft with a velocity-stage steam turbine. This unit, which has been developed by the De Laval Steam Turbine Co., weighs only about 1/10 as much as a duplex reciprocating pump of the same delivery and occupies only about ⅛ as much floor space and 1/15 as much cubical space.

The pump end contains two single-suction impellers cast from a special bronze and carefully finished to exact contours. Two impellers are used for pressures up to 200 lb. per sq. in. and three impellers for higher pressures. Single-stage boiler feed pumps have been built,

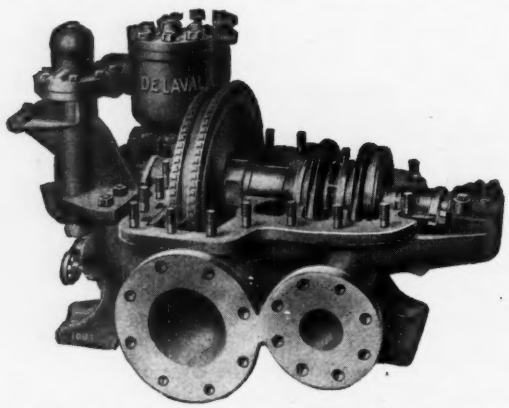


FIG. 1. DE LAVAL COMBINED TURBINE-DRIVEN CENTRIFUGAL BOILER FEEDER WITH CASING COVER REMOVED

but two or three stages are preferable because of the much longer life of the impellers at slower speeds. Each impeller discharges into a volute chamber by means of which the velocity in the water as it leaves the impeller is converted into pressure before the water is led to the eye of the succeeding impeller. This means of energy conversion is efficient over a wide range of delivery, and does not involve the use of small and sharp parts subject to rapid erosion.

The pump is hydraulically balanced and only one pair of labyrinth rings, surrounding the suction opening is required for each impeller except the last, which has two sets of rings.

The suction end of the pump is adjacent the turbine and the shaft packing between the turbine and pump chambers is hence subjected to turbine exhaust pressure on one side and the suction pressure on the other. A simple packing is therefore sufficient, and in any case, any small leakage of steam in one direction or of water in the other does no harm. As the leakage space adjacent to the balancing chamber at the discharge end of the pump is connected back to the pump suction, the packing about the shaft is subjected only to suction pressure. Aside from the intermediate packing there is only one steam packing, which is subjected to exhaust pressure.

The steam end of the unit consists of a velocity-staged turbine with either two or three rows of moving buckets, according to the steam economy desired. The nozzles can be proportioned for either high-pressure steam exhausting to feed heater or to condenser or for low-pressure steam exhausting to condenser, or the unit can be made interchangeable, thus permitting a great degree of flexibility in plant design. Where the exhaust steam from the boiler feeder is consumed in heating feed

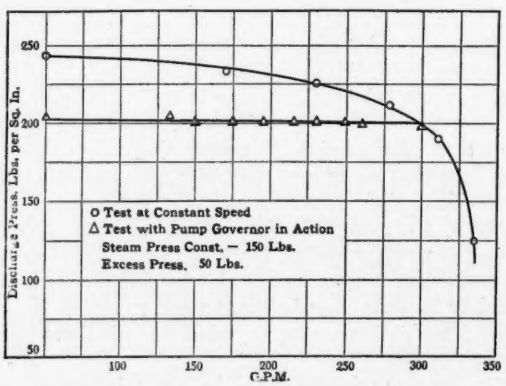


FIG. 2. HEAD DELIVERY CHARACTERISTICS DE LAVAL BOILER FEEDER UNIT

water, the thermal efficiency of the turbine-driven boiler feeder is high.

The unit is ordinarily fitted with a speed governor mounted upon the end of the shaft and when running at constant speed, the head varies with the delivery, as shown by the curved characteristic in the accompanying chart. In case of failure of the pressure governor to operate, the control of the unit is automatically taken over by the speed governor.

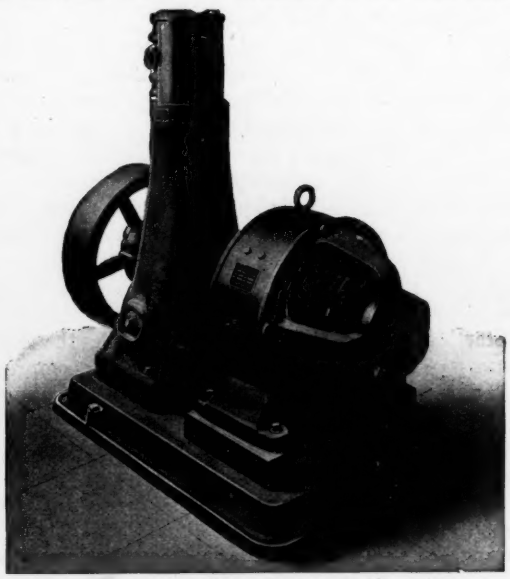
To provide against any possibility of racing, an emergency governor is also employed. This consists of a pin contained within a hole bored diametrically through the shaft. This pin is held by a spring from flying out under the influence of centrifugal force. When the speed reaches a certain point, the spring is compressed so that the pin strikes a trip, releasing

another spring by which the governor valve is closed at once and completely. The normal speeds of these pumps vary from 1800 to 3500 r.p.m., according to pressure and capacity.

The bearings are of the straight, ring-oiled type, and are all interchangeable. The entire rotating members and all wearing parts, with the exception of the governor valve, are accessible for inspection or removal upon lifting the casing cover and taking off the bearing caps, all of which can be done without breaking steam or water pipe connections.

Westinghouse-American Blower Generating Set

THE generating set illustrated herewith is for marine or stationary service and especially adapted for light or power service in small plants, and for exciters for large alternating-current generators. It consists of an American Blower Co. single or double-cylinder, automatic steam engine, and a type SK direct-current generator made by the Westinghouse Electric & Mfg. Co., direct-connected to the engine shaft. For lighting or power service the standard voltages are 125 and 250 v. For this service, generators are furnished having the compound field windings so proportioned that the same voltage is obtained at full load and no



WESTINGHOUSE-AMERICAN BLOWER GENERATING SET

load. For special system where 125 v. are required for lighting and 250 v. for power, the larger sized generators are supplied for 3-wire service; these 3-wire generators will take care of any unbalancing of the 2 sides of the system up to 10 per cent of full load.

Operation is simple and the set requires little attention. Even the oiling system is such that replenishing of the lubricant is necessary only infrequently. The generator is of forged open-hearth steel construction, with commutating poles and large non-leakable bearings protected from dust. It has automatic oil-ring lubrication, fixed brush position, is compact, strong and light in weight, has low operating temperature, and requires no skilled attention.

News Notes

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA announces the removal of its offices to Rooms 565-9, Union Arcade Bldg., Pittsburgh, Pa.

A BILL PROVIDING for licensing of steam and operating engineers has passed the Illinois Legislature, and now goes to the Senate for concurrence.

A. ALLAN & SON have recently moved from 486 Greenwich St., New York, to Harrison, New Jersey, where they have built a modern plant for making bearing metals. The facilities here enable the handling of orders more efficiently and those in charge of the plant are well able to maintain the standard of quality of the alloys upon which the business has grown.

THE SPLENDID INCREASE in business and the need for greater floor space and facilities for displaying Johns-Manville products, necessitated a change in location of the H. W. Johns-Manville Co., at Pittsburgh, on May 20. On this date, new and larger show rooms and sales offices were opened on the ground floor of the Westinghouse Building, corner of 9th St. and Pennsylvania Ave. These new quarters provide ample space to accommodate the increasing business, and are located in the heart of Pittsburgh's business district, within a few minutes' walk from the Union Station.

ON MAY 14 and 15, the first convention of the recently organized American Gear Manufacturers' Association was held at Hotel Shenley, Pittsburgh, Pa. This association was organized to develop, standardize and improve all products of the gear industry, and comprises men who represent companies engaged in this line of work. Various technical papers were read, dealing with problems of gear construction, and on Tuesday afternoon the delegates visited the works of the Westinghouse Electric & Mfg. Co., of East Pittsburgh, where they witnessed the method of manufacturing Bakelite Micarta for gears.

The officers elected were: President, F. W. Sinram, Cleveland; Vice-President, H. E. Eberhardt, Newark, N. J.; Secretary, F. D. Hamlin, Philadelphia; Treasurer, Frank Horsburg, Cleveland.

THE WESTINGHOUSE ELECTRIC & MFG. Co. has just announced the granting to its employes another advance in wages, effective May 16, amounting to 10 per cent. This will affect all of the workmen in the shop and practically all of the office force, except a few of the higher salaried employes.

This is one more of a number of raises in wages granted to the workmen of the shop, which raises represent a general increase, in a period of 2 yr., of practically 40 per cent.

The Westinghouse Co. has never made a practice of granting horizontal raises to the entire force, but has rather pursued the policy of granting the increases to cases of individual merit, basing them on the accomplishments of each individual employe. The gradual increase in the cost of living has made it imperative on the part of the company to enable its employes to meet these changed conditions.

The Westinghouse Electric & Mfg. Co. has also subscribed for a number of Liberty Bonds which it offers to

its employes, permitting them to pay in small monthly or semi-monthly installments. The management has laid out a comprehensive plan for handling subscription, making it easy for any employe to subscribe, and the advance in wages mentioned above will also serve to add to the facility with which these subscriptions may be made by the employes. The officers of the company say that the number of subscriptions for the bonds has been gratifying.

THE NINETEENTH annual summer session of the College of Engineering of the University of Wisconsin will be held at Madison during the six weeks period beginning June 25, 1917.

Special courses will be give in chemistry, electrical, steam and hydraulic engineering, gas engines, machine design, mechanical drawing, mechanics, shop work and surveying. All courses given in the university summer session are open to engineering students.

Special courses have been arranged for engineering, manual arts and vocational teachers.

For information, address F. E. Turneaure, Dean, Madison, Wis.

U. S. CIVIL SERVICE COMMISSION announces an examination for mechanical draftsman, Ordnance Department at Large. Present and future vacancies in the different ordnance establishments of the War Department will be filled from this examination. The usual entrance salary is $1320 a year.

It is desired to secure the services of a mechanical draftsman qualified in designing and laying out various buildings, also in estimating the cost of buildings and equipment. Competitors will be rated on general and technical education, experience and practical tests rated on work submitted. Applicants must have had at least 3 yr. experience as mechanical draftsman, of which at least 1 yr. has been spent on design or construction of mill or modern factory buildings, or have graduated from a technical school of recognized standing and have had not less than 1 yr. of special experience, and must submit with their applications one specimen of pencil drawing (mechanical, preferably along the special line of work specified above) executed by them, with a statement under oath that the drawings submitted are wholly the work of the applicant. These drawings should be such as to show clearly the applicant's ability in drawing and lettering. The title of the examination and the applicant's name and address should be lettered or written on each. Each applicant must state in his application the names and addresses of not less than two nor more than five persons who can testify regarding his technical training and experience. Applicants must have reached their twenty-third birthday on the date of making oath to the application. Until further notice applications will be received at any time, and the papers will be rated immediately upon their receipt, in order that appointments may be made with the least possible delay. Apply for Form 1312.

AT LAKEWOOD, OHIO, Millwrights Local No. 1142 has been organized and is forging ahead rapidly. Details in regard to its work can be had from F. A. Verlinden, 1502 Hopkins Ave.

Book Reviews

ELEMENTARY MECHANICS FOR ENGINEERS, by C. N. Mills; 4 by 7 in., 125 pages, illustrated, cloth binding; New York, 1916. Price, $1 net.

The book is an introduction to the subject of Mechanics, for those who have already had a considerable mathematical training. The author states that it is for students who have previously studied trigonometry, and a thorough knowledge of this subject is necessary in order to study this work satisfactorily. A knowledge of integral calculus is also desirable, although not absolutely essential. The subjects treated in the book are, the definitions of the various terms employed in mechanics, followed by chapters on linear and angular motion, vectors, kinetics, statics, motion in a circle and energy of rotation. It is a book intended for use in the classroom of technical schools, and for the purpose of an introduction to the subject is well suited, but would not be desirable as a book for home study work, unless the student had a thorough grounding in the branches of mathematics already mentioned. The treatment is clear and the arguments well put, and the figures are carefully designed to illustrate the text.

COMPRESSED AIR for the Metal Worker, by Charles A. Hirschberg. First edition, 1917; 315 pages, 5½ by 8½ in., illustrated; New York.

In the metal working field, the uses to which compressed air is put are multiplying rapidly, so rapidly that practical information in published form is scarce. Recognizing the situation, the author of this book has brought together a great amount of information dealing principally with the applications of compressed air, presenting data in tables and nontechnical form, compressed air equipment and methods of use are shown in numerous illustrations, which make the book easy to understand, and the information readily applicable to practical problems.

Starting with a short historical sketch, the author follows with several chapters dealing with the compressed air power plant, details of machinery, accessories, installation and care. Pneumatic tools then come in for description and the remainder of the book is devoted to the application of compressed air in the power plant, the foundry, machine shops, forge shops, boiler shops, structural steel plants, for hoisting, handling, conveying, for cleaning, for applying paint, lacquer, enamel, metal coating and for pumping liquids.

HOW TO RUN AN AUTOMOBILE, by Victor W. Page; 178 pages, 72 illustrations, cloth; first edition; New York, 1917. Price, $1.

In response to numerous requests for a concise exposition of the operating principles of modern gasoline automobiles, this book has been prepared. It is intended as an absolutely non-technical compilation of the operating instructions of leading automobile manufacturers including such instructions as apply to 1917 models, but is not intended as an instruction book on the construction and repair of self-propelled gasoline-driven vehicles. The volume will therefore find its greatest usefulness among motorists, dealers, chauffeurs, repairmen and all who may have occasion to operate this type of car.

These tables contain data especially worked out or carefully selected that are vital to your work. You may need them at any time and should preserve them. A handy, serviceable, loose-leaf cover in which these tables fit exactly, will be sent you for 30 cents in currency or stamps.

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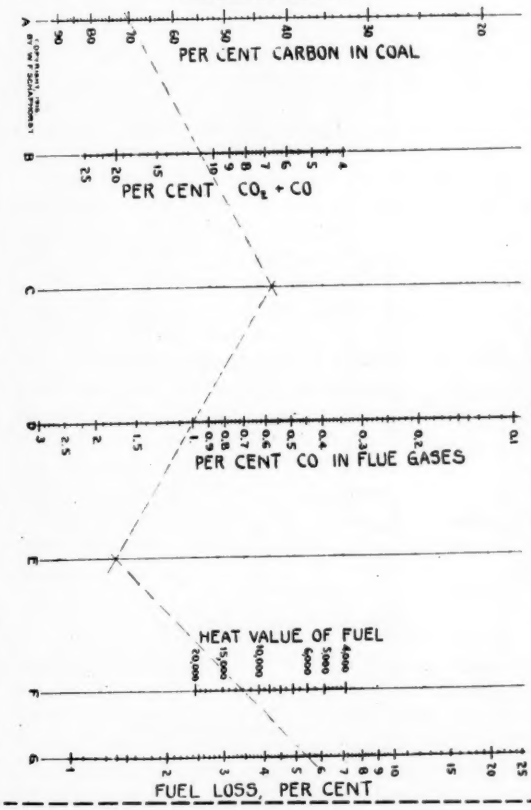
PRACTICAL ENGINEER



FUEL LOSS DETERMINED FROM FLUE GAS ANALYSIS

PRACTICAL ENGINEER

STANDARD SIZES FOR CARBON BRUSHES

ADOPTED BY THE ASSOCIATED MANUFACTURERS OF ELECTRICAL SUPPLIES

1. LENGTH OF ROUND AND RECTANGULAR BRUSHES

Up to and including 1¼ in.....increase by steps of ⅛ in.
Over 1¼ and to 3 in.....increase by steps of ¼ in.
Over 3 in.....increase by steps of ½ in.

Preference to be given steps of ¼ in. below 1 in. length and ½ in. above 1 in. length.

2. WIDTH AND DIAMETERS

Up to and including ¼ in.....increase by steps of 1/16 in.
Over ¼ in. to 2½ in.....increase by steps of ⅛ in.
Over 2½ in.....increase by steps of ¼ in.

It is recommended that ¼-in. steps be used wherever possible. Diameters of round brushes shall vary by steps of 1/16 in.

3. THICKNESS

Up to and including ¾ in.....increase by steps of 1/16 in.
Over ¾ in.....increase by steps of ⅛ in.

It is recommended that ⅛-in. steps be used wherever possible above ½-in. thickness.

4. LIMITS

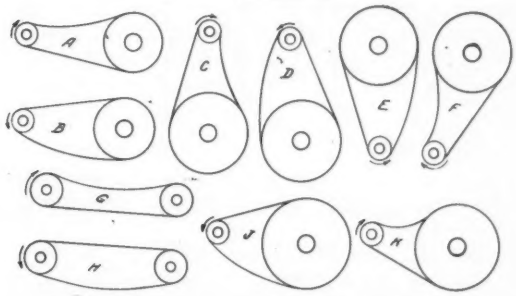
Rectangular and Square Brushes.

Length.....plus or minus 1/32 in.
Width.....exact size down to 1/64 in. undersize
Thickness—Plain brushes.....plus 0.001 in.
minus 0.003 in.
Plated brushes.....plus 0.001 in.
minus 0.004 in.

For square brushes thickness limits to apply to both the width and thickness.

PRACTICAL ENGINEER

RELATIVE POSITIONS OF SILENT CHAIN WHEELS



Silent chain drives will operate satisfactorily with almost any proportion and relative position of wheels, and with the slack either on upper or lower side. The accompanying cuts, A, B, C and D, show good practice.

When the center of the large wheel is directly over that of the smaller, as in E, the drive cannot be run with much slack in the chain. As a chain elongates with wear, it will be necessary to make frequent adjustments of center distance, or use an adjustable idler on the back of the chain to take out the slack and preserve proper contact of chain with small wheel.

If this drive can be slightly inclined, as at F, it will require less care and adjustment.

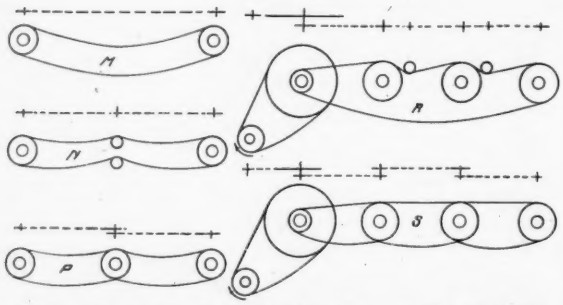
With horizontal drives having small wheels, it is preferable to have the slack on the bottom, as at H,

PRACTICAL ENGINEER

STORAGE BATTERY DISEASES AND REMEDIES

DISEASE	CAUSE	REMEDY
Loss of Capacity	Pores of plate clogged. Pores contracted. Loss of active material. Sulphatation. Loss of electrolyte.	Discharge battery, use negative plates as anodes and sheet lead as cathodes in 1.2 density sulphuric acid bath. See below. Add electrolyte.
Corrosion of plates.	Decomposition of dilute acid in pores of active material. Lead dissolving acids in electrolyte.	No remedy - get new plates. Change to pure electrolyte.
Fracture and buckling.	Charge carried too far, rate too rapid or current distribution on plate not uniform.	Refrain from too rapid rates and discharging too far. Keep electrolyte circulating. Keep excluded from light and heat.
Shedding of active material.	Unequal expansion of grid and active material, too rapid charging, overcharging.	Charge at low rates, do not overcharge, do not discharge too far, cover plates with some form of envelope.

RELATIVE POSITIONS OF SILENT CHAIN WHEEL (Continued)



rather than on top, as at G, for if the slack is allowed to accumulate, the chain is damaged by striking one strand against the other.

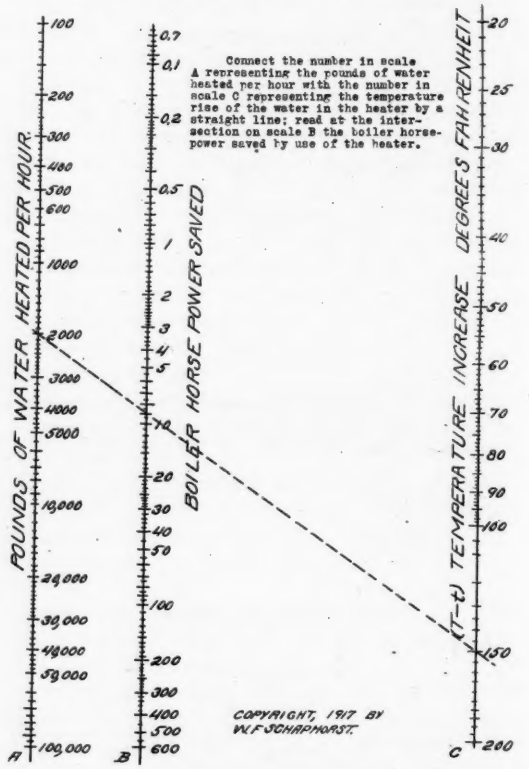
In horizontal or inclined drives with short centers, the slack should be on the bottom, as at J, for the accumulation of slack on top, as at K, would cause the chain to pinch between the wheels.

When the center distances are greater than about 25 ft., as at M, the chains should be supported by idlers, as at N, or preferably, the drive may be divided into two drives, as at P.

When it is desired to drive a number of shafts or rollers in parallel, if a single strand of chain is used, employ holding down idlers on the back of the chain, as at R.

It is preferable, however, to use individual short drives, as at S. —Copyright by Link-Belt Co.

SAVING DUE TO HEATING FEED WATER


Connect the number in scale A representing the pounds of water heated per hour with the number in scale C representing the temperature rise of the water in the heater by a straight line; read at the intersection on scale B the boiler horsepower saved by use of the heater.
POUNDS OF WATER HEATED PER HOUR
BOILER HORSE POWER SAVED
(T-t) TEMPERATURE INCREASE DEGREES FAHRENHEIT
A
B
C
COPYRIGHT, 1917 BY W.F. SCHAPHORST.

STORAGE BATTERY DISEASES AND REMEDIES

DISEASE	CAUSE	REMEDY
Sulphatation	Over discharge or too rapid discharge.	Long slow charge at minimum rate
Reversal of negative plates.	Defective cell in battery completely discharged and continued charge in reverse direction.	Recharge cell and continue charge up to normal condition.
Internal discharge.	Impurities in electrolyte.	Use pure electrolyte, keep plates covered.
Hardening of negatives in air.	Oxidization, occlusion, heating.	Continued overcharge against dummy positives.
Loss of voltage.	Abnormal amount of sulphate in active material.	Reduce sulphatation - see above.

STANDARD SIZES FOR CARBON BRUSHES—Continued

Round Brushes

Diameter—
Up to and incl. ¼ in.....exact size to 0.006 in. undersize
5/16 and 3/8 in.....exact size to 0.008 in. undersize
7/16-in. and above.....exact size to 0.010 in. undersize
Length.....plus or minus 1/32 in.

Box gauges to be used for thickness and diameter.

5. LENGTH OF SHUNTS

It was decided that no standard lengths could be used, but it was agreed to define the length of a shunt as the distance from the top of the brush to the center of the slot or hole in the terminal.

6. HOLES OR SLOTS IN SHUNT TERMINALS

It was decided that exact sizes are not essential, but that the following shall be adopted as a maximum for the screws specified, and the minimum shall allow sufficient clearance to permit the screw entering the slot or hole without binding.

No. 8 and No. 10 screws..... 7/32-in. hole or slot
No. 12 and No. 14 screws..... ¼-in. hole or slot
5/16-in. screw.....11/32-in. hole or slot
3/8-in. screw.....13/32-in. hole or slot

7. BEVELS

Bevels on carbon brushes shall vary by steps of 5 degrees and shall be accurate to within 1 degree above or below.

The length of a beveled brush shall be the distance from the end to the toe of the bevel, if beveled on one end only, or the distance from toe to toe measured parallel to the face of the brush when both ends are beveled. In other words, the length will be that of the square-ended brush from which the beveled brush was made.

8. PLATED BRUSHES

Dimensions, limits, etc., to be the same as for plain brushes, except thickness limits, for which see Paragraph 4.

Chapter I is devoted to a discussion of the various parts of an automobile and their various functions. Chapter II to general starting and driving instructions, and Chapter III to typical 1917 control systems. Care of automobiles in general, storage batteries, tools and repair equipment, supplies, motor troubles, etc., are subjects taken up in the fourth and concluding chapter.

ORGANIZATION IN ACCIDENT PREVENTION, by Sidney Whitmore Ashe, Head of the Educational and Welfare Department of General Electric Co., Pittsfield Works; 130 pages, 6 by 9, illustrated. Price, $1.50.

Definite methods of preventing accidents, and practical methods of caring for those that commonly occur, are given in this book, which tells how safety work may be successfully organized at a minimum of expense. It is divided into chapters as follows: Chapter I—Fellowship, System, Education, Discipline; II—Specific Accidents Which May Be Reduced by Educational Means; III—Medical and Physical Examination of Employes with Special Reference to Tuberculosis and Hernia; IV—Emergency Hospitals and First Aid Work; V—Records, Analysis, Ratio Curves; VI—Accident Relationship.

Catalog Notes

THAT ELECTRICITY is invading every line of human endeavor is well known, but that there are more than 3000 applications of electric current in 109 trades and industries has hardly been appreciated. The Society for Electrical Development after an exhaustive research has just issued a booklet listing these applications. It has been sent free to all members of the Society.

"More than 3000 Uses for Electricity" is a complete, up-to-date guide for sales managers, contractors and all sellers of electric service. It reminds them at a glance of new possibilities for the sale of additional energy in their localities. In these days, every trade and industry is giving special attention to modernizing its equipment on a more efficient and profit-producing basis. The application of electricity in these lines of business, and elimination of old and obsolete methods, is every electrical man's war-opportunity. This booklet is one of a carefully planned series to be issued in connection with The Society for Electrical Development's "Keep Business Going" campaign.

THE INGERSOLL-RAND CO., 11 Broadway, New York, have recently issued two new catalogs as follows:

Form 3311, 20 pages, 6 by 9, covering Imperial Type X duplex steam driven compressors suitable for general industrial application of compressed air. The catalog gives tables of sizes and capacities and is thoroughly illustrated to show the machine in detail.

Form 8507, 40 pages, 6 by 9, covers Little David pneumatic drills. Various types and models are shown with recommendations as to the particular character of work for which they are adapted. Each tool is illustrated and the several tables give the sizes and capacity of each.

Copies of these bulletins will be sent free on request to the company's nearest branch office.

THE DE LAVAL STEAM TURBINE CO., of Trenton, N. J., builder of steam-turbine-driven centrifugal pumps, has just issued, under the title "Progress in Water Works Pumps," a 48-page booklet discussing the general economic and engineering conditions affecting the design and installation of such pumps. Installations in 15 of the principal cities of this country and Canada are described, including 34 units aggregating 999,000,000 gal. per day capacity. The publication should be of value to anyone interested in the handling of water in large quantities.

OVALHOLE Hollow Center packing is described and illustrated in a circular from Hollow Center Packing Co., 608 S. Dearborn St., Chicago.

SIZES and list prices of the Powell injector are given in a booklet recently issued, which may be had on application to The Wm. Powell Co., Cincinnati, O.

CROSSHEAD-GUIDED expansion joints and Multi-Head water heaters made by Ross Heater & Mfg. Co., Buffalo, N. Y., are illustrated and described in a new folder from that company.

THE EDWARD VALVE & MFG. CO., Chicago, has issued its 1917 Catalog No. 6, covering a full line of cast steel, forged steel and bronze blowoff valves and globe valves, also atmospheric relief valves, unions, fittings, etc.

WAGON AND TRUCK LOADERS for handling coal, coke, stone, sand, fertilizer and similar loose materials from ground storage are illustrated and described in Catalog 270 from Link-Belt Co., 39th St. and Stewart Ave., Chicago.

LEATHER BELTING, belt lacing, lace leather, belt cement, belt dressing, round leather belting, rawhide rope and hydraulic leather are described, illustrated and listed in a new catalog from Chas. A. Schieren Co., 30-38 Ferry St., New York.

REDUCING VIBRATION and Noise is the title of a booklet published by Armstrong Cork Co., Pittsburgh, Pa., and relating to the subject of Nonpareil Cork Machinery Isolation.

Copies will be supplied free of charge upon request to the company.

CROCKER-WHEELER CO., Ampere, N. J., recently issued the following bulletins: No. 173, Slot-Bridge Construction for Induction Motors; No. 174, Form L Direct-Current Machines, 115, 230 and 550 v., motors 1/5 to 7½ hp., generators 0.4 to 5 kw.; No. 175, Form I Direct-Current Machines, medium size for general use, motors 3¾ to 50 hp., generators 3 to 45 kw.; No. 176, Form R Induction Motor, 2 and 3-phase, squirrel-cage type, 25-cycle.

FOUR NEW Link-Belt booklets which are reproductions of trade journal articles written by the company's engineering staff, have been received, as follows:

Traveling Water Screens for Condenser Intakes, No. 305.

Blue Diamond Coal Co., Tipple, No. 308.

Increasing Profit by Saving Expense in the Handling and Storing of Coal and Ashes, No. 304.

Some Modern Coal Tipples, No. 303.

The company will be glad to send copies of any or all of these publications to those interested.

LINK-BELT CO.'S most recent Link-Belt Silent Chain Booklet, entitled, "The Ideal Drive for Grain Elevators," was lately received.

A RECENT NUMBER of The Blowoff, issued by Yarnall-Waring Co., Chestnut Hill, Philadelphia, contains the third prize article on "Closer Co-operation Between Engineer and Plant Owner."

FROM A. E. KRAUSE, 227 Morris Ave., Mountain Lakes, N. J., we recently received a booklet discussing the Krause absorbent filter for purifying oily condensate feed water without the use of chemicals.

PEROLIN—the Boiler Metal Treatment, is the subject of a pamphlet from Perolin Railway Service Co., St. Louis, Mo., explaining the operative principles of a mineral liquid which cleans the interior surfaces of boilers by mechanical action.

THE GENERAL ELECTRIC CO. has just issued Bulletin No. 43,503 on The Application of Novalux Units to Ornamental Street Lighting. The bulletin is attractively prepared, containing 36 pages fully illustrating the correct lighting units for business streets, residential streets and outlying districts, and will be found a valuable guide in the selection of modern street lighting units.

Trade Notes

THE HOPPES MFG. CO. recently appointed O. L. Collins & Son, 623 Bank of Commerce Bldg., St. Louis, Mo., its St. Louis representatives to handle its entire line of steam specialties.

DIRECT BRANCH OFFICES of the Wright Mfg. Co. and the Austin Separator Co. have been established at 30 Church St., New York City, in order to get more closely in touch with customers in the eastern states, and insure prompt and satisfactory service.

THE NEW 60,000-kw., three-cylinder, compound electrical unit to be installed in the 74th St. station of the Interborough Rapid Transit Co., New York, where three 30,000-kw., cross compound Westinghouse turbine generators have been in successful operation for over 2 yr., will consist of a high-pressure and two low-pressure turbines, each coupled to a generator. Each of the three turbo generators making up the unit is to have a governor so arranged that if for any reason the circuit should open on the high-pressure turbo generator, steam will be shut off from that particular one and the two low-pressure turbo generators will operate under governor control with high-pressure steam. Likewise, should anything happen to both the high-pressure and one of the low-pressure turbo generators, or to the two low-pressure turbo generators, the remaining one will operate and carry the load.

The turbines which will operate at 220 lb. absolute steam pressure, 120 deg. superheat, 20-in. vacuum and the generators which will have a capacity of 60,000 kw. continuously or 70,000 kw. for 2 hr., are being furnished by the Westinghouse Electric & Mfg. Co., of East Pittsburgh, Pa.

PRACTICAL ENGINEER

Trade-mark, Reg. U. S. Pat. Off.

PUBLISHED ON THE FIRST AND FIFTEENTH OF EACH MONTH

SEMI-MONTHLY

Subscription price in advance in the United States, Mexico or united possessions, $1.00 a year.

In Canada, subscription price, $1.75 a year.

Foreign Countries, subscription price, $2.50 a year.

Address all letters and make all checks and money orders payable to Technical Publishing Co., 537 S. Dearborn St., Chicago, Ill.

Any advertiser is invited to examine our paid subscription lists and Post Office mailing receipts at any time.

ADVERTISING RATES

Display

Full page, one year, each insertion, $66.00.

Half page, one year, each insertion, $38.50.

Quarter page, one year, each insertion, $22.00.

Eighth page, one year, each insertion, $13.25.

Front cover, $175.00 per issue.

Other specified positions, regular rate plus 10 to 50 per cent.

Stippled plates used, but no heavy, black and white plates.

Classified Rates

Per line, 30 cents each insertion.

Advertisements in this section are inserted under regular headings.

No display type allowed, but the first three words may be set in capital letters.

About nine words make a line. Minimum space sold, two lines.

Under classification "Position Wanted," advertisements not exceeding four lines will be inserted once for subscribers free of charge.

All copy should be received at Chicago office 18 days before date of publication.

Circulation of this issue, 22,000.

Technical Publishing Co.

537 S. Dearborn Street

Chicago

Position Wanted

POSITION WANTED—By young man 21 yrs. in a power plant of 1000 kw. or more where there is a good chance for advancement. Not particular about wages or kind of work to start with. Have had a year's experience night engineer in 25 kw. plant and one year as head of 200 hp. heating plant. Can furnish best of references. Strictly sober. Am anxious to learn, but patient. Address Box 200, Devil's Lake, N. D.
4-15-3

POSITION WANTED—As chief engineer. Have had 10 years' practical experience. Especially qualified to handle the plant on an efficiency basis, reducing coal consumption and operating costs. Must locate in Chicago. Presently employed, but have good reasons for desiring a change. Address Box 479, Practical Engineer, 537 S. Dearborn St., Chicago, Ill. 6-1-1

POSITION WANTED—By steamfitter with 17 years' experience at the trade. Can furnish references as to habits and ability to handle men. I am 33 years old. Married. Address J. H. D., 669 Wunderlick St., Barberton, O. 6-15-1

POSITION WANTED—By thoroughly competent man with 11 years' experience as engineer and assistant superintendent in sugar factories in Cuba, Mexico and Louisiana. Good steamfitter and machine repairman. Have had charge of 10 steam boilers and 6 ammonia compressors as day and night engineer. Can speak English, Spanish and some German. Single. 26 years old. Can furnish good references. Address Box 480, Practical Engineer, 537 S. Dearborn St., Chicago, Ill. 6-1-2

POSITION WANTED—Fireman with first-class Mass. license would like to locate near Boston, Mass. Day work, 8 or 10-hour day. Sober and reliable. Best of references. Address R. C., 17 Cozenore St., Boston, Mass.

POSITION WANTED—By engineer competent to operate Corliss and high speed engines and turbines. Familiar with a.c. and d.c. generators and refrigeration. Age 27. Married. Sober. Desire position around New York. Address A. Kahel, 233 S. 4th St., Brooklyn, N. Y.

POSITION WANTED—By man 30 years old, good habits, married, with 6 years' experience in steam electric plants. Would like position as engineer in plant of 2500 kw. capacity or more, where I can advance myself. Address Box 471, Practical Engineer, 537 S. Dearborn St., Chicago, Ill. 6-1-2

POSITION WANTED—Young man, age 28, as engineer in New York or Brooklyn. Hold marine, stationary and refrigeration license. Day work, 8-10 hours, desires to go to school nights. Write for particulars. Box 452, Practical Engineer, 537 S. Dearborn St., Chicago, Ill. 5-1-4

POSITION WANTED—As oiler, by young man, age 21, single. Willing to accept position in any city. Address Peter Stanys, 670 W. 18th St., Chicago, Ill. 6-1-1

POSITION WANTED—As fireman or oiler in large plant; 3 years' experience as fireman, 18 months as assistant engineer. Married. Strictly sober. Prefer Southern States. L. C. Drake, Cambridge City, Ind. 6-15-1

POSITION WANTED—as chief engineer in industrial plant, Missouri, Arkansas, Kansas, Iowa or Nebraska, or as Superintendent of light and water plant in city of 2500 to 8000. Ten years' practical experience with steam, electrical and water systems. Technical training. Now employed by U. S. Government as engineer and instructor. Executive ability. Can report on 15 to 30 days' notice. Married. Age 30. Address Practical Engineer, Box 466, 537 S. Dearborn St., Chicago, Ill. 6-1-1

POSITION WANTED—By young man, 23 yrs. old, as fireman or oiler in ice and electric light plant in City of St. Louis. Have had one year's experience in firing and some experience in steam engineering. Address Leonard Ochs, 1536 Papin St., St. Louis, Mo. 6-1-2

POSITION WANTED—As engineer in small power plant. Five years' experience as engineer in grain elevator. Good mechanic. Steady and sober habits. Single. 28 years old. Central states preferred. Box 115, Walcott, Iowa. 5-15-3

POSITION WANTED—By engineer; have Ohio engineers' and boiler inspectors' licenses. Experienced with absorption method of manufacturing gasoline. Good references. Address Box 481, Practical Engineer, 537 S. Dearborn St., Chicago, Ill. 6-1-2

Help Wanted

WANTED—Resident subscription agents in the following cities: Atlanta, Ga.; Cincinnati and Columbus, Ohio; Kansas City, Mo.; Los Angeles, Cal.; Louisville, Ky.; Newark, N. J.; New Orleans, La.; Portland, Ore.; St. Louis, Mo.; San Francisco, Cal.; Washington, D. C. This is an excellent chance for a hustler who is familiar with power plant conditions, to turn his spare time into dollars. To such a one we offer a Real Opportunity. Write Subscription Department, Practical Engineer, 537 S. Dearborn St., Chicago, Ill. tf.

Wanted

WANTED—Agents on commission to sell our shaking grates. We will install grates on trial or put it to test at our expense with any grate made. Address Armstrong Mfg. Co., Springfield, Ohio. tf.

WANTED—Agents handling engine and boiler room specialties in every section for side line paying large commissions. Give experience, line carried and territory covered. Box 381, Practical Engineer, 537 S. Dearborn St., Chicago, Ill. tf.

For Sale

FOR SALE—75 Kw. G. E. 125-250 volt 3-wire generator, dir. con. Buckeye side-crank engine, like new, $1,250. Two 40 Kw. G. E. 125 volt belted generators, $300 each; 13x13 Chuse automatic engine, $300. Power Machinery Exchange, Jersey City, N. J.

WANTED—Marine boilers. We will pay cash awards for information that leads to a purchase by us of marine boilers of from 75 H. P. to 250 H. P. The Pittsburg Boiler & Machine Co., Pittsburg, Kansas. tf

Patent and Patent Attorneys

PATENTS THAT PROTECT AND PAY—Advice and books free. High references. Best results. Promptness assured. Send sketch or model for search. WATSON E. COLEMAN, Patent Lawyer, 624 F St., N. W., Washington, D. C. tf.

PATENTS—C. L. Parker, Attorney-at-Law and Solicitor of Patents. Patents secured promptly and with special regard to the legal protection of the invention. Handbook for inventors sent upon request. Washington, D. C. tf.

PATENTS—H. W. T. Jenner, Patent Attorney and Mechanical Expert, 606 F St., Washington, D. C. Established 1883. I make a free examination and report if a patent can be had and the exact costs. Send for full information. tf.

A. P. CONNOR, Consulting Electrical and Mechanical Engineer, Attorney-at-Law and Solicitor of Patents and Trade-Marks. Results guaranteed. 121 Carroll St., S. E., Washington, D. C. tf.

PATENTS—Send sketch for free search and reports. Books and patents and book of reference letters sent free. John S. Duffie & Co., 612 F St., Washington, D. C. tf.

PATENTABLE IDEAS WANTED—Send for three free books. R. B. Owen, 28 Owen Bldg., Washington, D. C. tf.

Technical Books

FREE ENGINEER BOOKS and power plant tools and specialties, for securing new subscribers for Practical Engineer. A dandy chance for the engineer with a little spare time to get some fine premiums. Send for free descriptive circular and terms. Subscription Department, Practical Engineer, 537 S. Dearborn St., Chicago, Ill.

Miscellaneous

ENGINEERS, DO YOU WANT to utilize your exhaust steam for heating or drying purposes without back pressure on your engine? If so, address Monash Engineering Co., 1413 Jackson Blvd., Chicago, Ill. tf.

Sparks From The Advertising Pages

Advertising men of the United States will play an important part in the war. Such was the theme at the recent convention of the Associated Advertising Clubs of the World.

The delegates were told of the importance of advertising in the working out of the war policies of Great Britain and Canada. J. Murray Allison, former advertising manager of the London Times and now publisher of Land and Water, tabulated what advertising had done for England.

He listed the achievements as follows:

"It raised 3,000,000 fighting men under the voluntary system.

"It raised countless billions of dollars in loans floated in England.

"It raised millions in private donations for the various war charities, the majority of which were run by advertising men.

"It discovered to the authorities over 1,000,000 men whose trades and their knowledge of those trades made them skilled munitions workers.

"It persuaded over 1,000,000 women to offer their country the labor of their hands, to release the male workers for other duties.

"Advertising taught the people of Great Britain to work harder and produce more, to give up their useless luxuries when it was necessary to consume less petrol and less rubber."

Likewise Mr. John M. Imrie of Toronto, Manager of the Canadian Press Association, spoke on "Advertising Canada's Problems" and told of how the government conducted 17 distinct advertising campaigns, which he described.

To keep Canada's bumper apple crop of 1914 from going to waste when the foreign market was cut off by the war, an apple advertising campaign was launched to create a home market. A booklet of 209 apple recipes was printed, and 65,000 copies were distributed. This campaign was a success.

A campaign of information for farmers, as to the best means of increasing the yield per acre, was followed by a 10 per cent increase in production, and this campaign has been repeated. Three domestic war loans, aggregating $500,000,000, were subscribed after a general advertising campaign.

War Savings Certificates and debenture stocks are other forms of Government securities that have been floated by advertising.

The thrift movement, to eliminate waste, was the subject of another advertising drive, and the Canadian minister of finance estimated last March that the saving effected by the people had been $500,000,000. Another popular movement exploited in the same way was thrift gardening.

The raising of money for the Canadian Patriotic Fund, for soldiers' families, and for the Red Cross and the Belgian and Servian relief funds, was carried on largely through advertising. Toronto, a city of 500,000 persons gave $3,500,000.

Women were persuaded to take employment in munitions plants by a special series of advertisements, and 600 munitions plants are in operation, with 60,000 women workers. Farm labor was advertised for in the United States, as well as in Canada.

All the above items prove the tremendous power of advertising. In this country Advertising will be used as a stabilizer of Business and its potent influnence will be felt in all lines of endeavor. And in addition to maintaining the equilibrium of Business it will be influential in causing money to gravitate to the orgainzed sources of relief as well as vitally contributing to the success of "Our" Liberty Loan.